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The study of interaction between student characteristics and teaching methods on achievement of selected drafting concepts

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The study of interaction between student characteristics and teaching methods on achievement of selected drafting concepts

by

Wen-Shung Tai

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CHAPTER I. INTRODUCTION

With the widespread use of intelligence and achievement tests, the educator has realized that students vary greatly as individuals and has recognized the importance of individualized instruction, that is, adapting the educational environment to individual differences. The general hypotheses underlying such adapted instruction is that some students will show greater achievement under one mode of presentation of subject matter while other students will show greater achievement under an alternative mode. Therefore, Borg and Gall (1983) pointed out that "improvement in learning and education may result from effort to match instruction methods and programs with students who are best to learn from them."

Individualized instruction was not proper two decades ago due to the limitation of cost, time, and the lack of efficient teaching assisted instruments. Recently, this problem has been overcome with the development of computer and computer-assisted instruction (CAI) packages. Rushinek, Rushinek, and Stutz (1983) indicated that "computer-assisted instruction, as a supplement to traditional classroom instruction, is often used in an attempt to improve students' learning." Cavin, Cavin, and Lagowski (1981) indicated that not only can the use of computer-assisted instruction improve the student learning, but it also can produce an improvement in students' attitudes toward the subject matter being studied. Thus, it appears possible that the use of CAI materials, even if they are not directly related to the material required for the course, could produce an improvement in attitude toward the subject matter.

Statement of the Problem

The problem of this study was to examine the effect on the achievement of drafting concepts of the interaction between student characteristics and two teaching strategies: traditional lecture and computer-assisted instruction.

Purpose of the Study

The purpose of this study was to identify specific characteristics that correlate with achievement and attitudes measures on selected drafting concepts under two teaching strategies: traditional lecture and computer-assisted instruction.

More specifically, the purposes of this study were

1. To develop the instruments to measure the students' attitude toward computers and drafting;
2. To identify the interaction between selected student characteristics;
3. To measure the effect of computer-assisted instruction on achievement of selected drafting concepts;
4. To examine the relationship between attitudes and achievement.

Need of the Study

Student characteristics are of central importance in education. They play a crucial role in learning theory and teaching strategies. Since the beginning of this century, many articles and books have been published on this topic. Recently, due to the development of computers and computer assisted teaching methods, educators give increasing attention to research on the relationships between student characteristics and teaching strategies.

A number of studies related to the relationships between student characteristics and teaching strategies have been published. Born and Davis (1984); Kulik, Kulik, and Carmichael (1974) indicated that the general personalized system of instruction (PSI) model produces significantly more positive student attitudes toward a course and/or significantly higher achievement when compared with conventional lecture approaches. Reiser (1977) indicated that the effect of various pacing procedures on achievement in PSI courses vary according to student perception reinforcement. Cronbach and Snow (1969) and Skames, Sullivan, Rowe, and Shannon (1974) had shown that IQ interacted significantly with treatment. Salomon (1974) pointed out that aptitudes interacted with teaching methods.

Dahl (1984) pointed out that "the interaction between treatment (CAI strategy) and cognitive learning styles was not significant." Wiggins (1984) indicated that a significant difference was not found in achievement scores when the students were grouped by their pretest attitude scores but not by teaching methods.

The above studies are not particularly conclusive or consistent. Thus, individualized instruction may be more effective for a subgroup of students at certain levels of particular characteristics, while conventional methods may be more appropriate for another subgroup of students at different levels of the same characteristics. For still another subgroup, achievement may be unaffected by instructional treatment. These conflicting findings may stem in part from heterogeneous experimental conditions and failure to employ an appropriate instrument for the analysis of the interaction between student characteristics and instructional method. Tobias (1976) pointed out that attribute-treatment interaction (ATI) may be highly specific and may vary for different content. Tobias further pointed out that "ATI" had limited generality across subject matter and failed to enlighten researchers regarding the pattern of interaction in other areas. Therefore, the purpose of this study was to examine the interactive effect of students' GPA, ACT scores, former performances and experiences on drafting and computer, attitudes toward computer and drafting, and instructional method on achievement and attitude in a drafting course taught by both CAI and conventional approaches.

Hypothesis of the Study

The independent variables included in multiple regression equations in order to determine the effect on the dependent variables (achievement and attitude) were students' ACT score, College GPA, pretest scores of attitudes toward subject matter and computers, pretest scores of achievement, and former experience with computers and drafting.

The following null hypotheses were used to test the hypothesized relationships:

1. There will be no significant difference of posttest achievement scores between subjects exposed to traditional lecture and students exposed to computer-assisted instruction.

2. There will be no significant interaction between the treatment and aptitude in relation to subject's score on post drawing achievement test.

3. There will be no significant interaction between the treatment and pretest attitude in relation to subject's score on the post drawing achievement test.

4. There will be no significant interaction between the treatment and previous experiences in relation to subject's score on the post drawing achievement test.

5. There will be no significant difference of posttest scores of attitude toward computers between subjects exposed to traditional lecture and computer-assisted instruction.

6. There will be no significant interaction between the treatment and aptitude in relation to subject's posttest score on the attitude toward computers.

7. There will be no significant interaction between the treatment and pretest attitude in relation to subject's posttest score on the attitude toward computers.

8. There will be no significant interaction between the treatment and previous experiences in relation to subject's posttest score on the attitude toward computers.

9. There will be no significant difference of posttest score of attitude toward drawing between subjects exposed to traditional lecture and students exposed to computer-assisted instruction.

10. There will be no significant interaction between the treatment and aptitude in relation to subject's posttest score on the attitude toward drawing.

11. There will be no significant interaction between the treatment and pretest attitude in relation to subject's posttest score on the attitude toward drawing.

12. There will be no significant interaction between the treatment and previous experience in relation to posttest score on the attitude toward drawing.

13. There will be no significant change in scores of attitude toward graphic subject matter obtained prior to and following instruction under the two treatment modes.

14. There will be no significant difference between pre- and postscores measuring the attitude toward the use of computers under two treatment modes.

Assumptions of the Study

For the purpose of the study, the following assumptions were made:

1. The selected student characteristics are appropriate for studying interaction with teaching methods.

2. Attitude is identifiable and measurable.

3. Attitude is a psychological continuum, the scale value of attitudes vary from negative infinity to positive infinity.

4. The instruments developed for measuring student performance and attitudes are valid.

5. Subjects who responded to the instrument perceived the meaning of each item identically and answered the items based on their true feeling toward computers and drafting.

6. Student attitudes and achievement are affected by instruction methods.

7. Students who enrolled in the department of Freshman Engineering at Iowa State University represented the population of this study.

Limitations of the Study

This study was conducted under the following limitations:

1. Samples were limited to students at Iowa State University enrolled in Freshman Engineering 170 during the Fall semester 1986.

2. The student characteristics for this study were limited to general abilities (ACT scores), former performances (college GPA, numbers of course taken in the drafting and computer areas), sex, educational level, major, and attitudes toward computers and drafting.

3. The drafting concepts selected in this study were limited to those related specifically to orthographic projection.

4. The measurements of attitudes were limited to a self-reported method.

Procedure of the Study

1. Review of literature. A review of literature was undertaken to identify current theories and research related to the interaction between student characteristics and teaching methods.

2. Determination of population of the study. The population of this study consisted of individuals who were enrolled in the department of Freshman Engineering.

3. Samples selection from the population. The sample for this study consisted of individuals who enrolled in Freshman Engineering 170. Two sections were randomly selected as control groups using traditional lecture, the other two sections were experimental groups using computer-assisted instruction.

4. Select drafting concepts for experiment based on the outline of Freshman Engineering 170 course.

5. Develop the computer-assisted instructional program based on selected drafting concepts.

6. Identify a theoretical domain of attitudes regarding computers and engineering drawing.

7. Develop attitude instruments to measure student attitudes toward subject matter and computers.

8. Develop an achievement instrument to measure student performance on selected drafting concepts.

9. Validate the content and the appropriateness of the constructed tentative instruments and computer-assisted instructional program.

10. Revise the instruments and CAI program based on the analysis of procedure 9.

11. Conduct a pilot test to try out the instruments and CAI program.

12. Conduct an item analysis based on the pilot test data.

13. Revise the instruments and CAI program based on the results of the pilot test and item analysis.

14. Conduct the field test (experimentation) and administer the achievement and attitude tests before and after treatment.

15. Conduct the data analysis:

Model 1 (covariates):

$$\hat{Y}_i = \Sigma B_j X_j + B_0 \text{ where } i = 1 \text{ to } 3 \text{ and } j = 2 \text{ to } 8$$

Model 2 (adjusted treatment):

$$\hat{Y}_i = \Sigma B_j X_j + B_1 X_1 + B_0 \text{ where } j = 2 \text{ to } 8$$

Model 3 (interactions):

$$\hat{Y}_i = \Sigma B_j X_j + B_1 X_1 + B_K X_K + B_0 \text{ where } K = 9 \text{ to } 15$$

Test for treatment is:

$$F_{(df_2-df_1, N-df_2-1)} = \frac{(R_2^2 - R_1^2)}{(1 - R_2^2)} \cdot \frac{(N - df_2 - 1)}{(df_2 - df_1)}$$

Test for interaction is:

$$F_{(df_3-df_2,N-df_3-1)} = \frac{(R_3^2 - R_2^2)}{(1 - R_3^2)} \cdot \frac{(N - df_3 - 1)}{(df_3 - df_2)}$$

where

$\hat{Y}_1$ = Posttest achievement (Posttest)

$\hat{Y}_2$ = Posttest attitude toward computers (Posdratt)

$\hat{Y}_3$ = Posttest attitude toward drawing (Poscsatt)

X_1 = Treatment

X_2 = ACT

X_3 = Pretest achievement (Pretest)

X_4 = GPA

X_5 = Number of semester drawing courses taken in high school and in college (Drawing)

X_6 = Number of semesters computer courses taken in high school and in college (CS)

X_7 = Pretest attitude toward drawing (Predratt)

X_8 = Pretest attitude toward computers (Precsatt)

X_9 = Treatment x ACT

X_{10} = Treatment x GPA

X_{11} = Treatment x Pretest

X_{12} = Treatment x Predratt

X_{13} = Treatment x Precsatt

X_{14} = Treatment x Drawing

X_{15} = Treatment x CS

16. Finish the research report based on the results of data analysis.

Definitions of Terms

Aptitude. Aptitude refers to any individual difference variable which functions selectively with respect to learning, that is, which appears to facilitate learning in some instructional treatments while limiting or interfering with learning in other student and other instructional treatments (Snow and Salomon, 1968).

Aptitude-Treatment Interaction (ATI). Aptitude-Treatment Interaction refers to "any characteristic of the individual that increases or impairs his probability of success in a given treatment" (Cronbach and Snow, 1969).

Attitude. Attitude refers to the predispositions individuals have which cause them to respond to events, persons, objects, or ideas in certain ways.

Computer-Assisted Instruction. Computer-assisted instruction refers to the utilization of a computer to assist in the learning process in the various ways depending on the structure and type of program.

Individualized Instruction or Personalized System of Instruction (PSI). Individualized instruction or personalized system of instruction (PSI) refers to the matching of an instructional method with individuals' background, talents, abilities, interest, and the nature of past performances and experiences.

CHAPTER II. REVIEW OF LITERATURE

This chapter is to synthesize and present articles which pertain to the research topic in the areas of (1) attitude and (2) computer-assisted instruction (CAI). In the first area, the definitions of attitude, the nature of attitude, the theory of attitude development and change, the measurement of attitude, and the relationship of attitude and performance are discussed. The second area is concerned with the varieties of CAI, the characteristics of CAI, and the effectiveness of CAI on achievement and attitude.

Attitude

Definition of attitude

Doob (1947) defined attitude as an implicit, drive-producing response of social significance to the individual. He further indicated that an attitude is an implicit response which is both anticipatory and mediating in reference to patterns of overt responses, which is evoked by variety of stimulus patterns as a result of previous learning or of gradients of generalization and discrimination, which is itself cue- and drive-producing and which is considered socially significant in the individual society.

Champbell (1963) defined attitude as "acquired behavioral dispositions." McDonald (1965) expanded this definition more specifically as that attitude is "a predisposition to act in a positive or negative way toward persons, objects, ideas, and events."

Snow (1965) defined attitude as a mental and neural state of readiness, organized through experience, exerting a directive or dynamic influence upon the individual's response to all objects and situations to which it is related.

Magoon and Garrison (1976) defined attitude as "a tendency to respond to an object, symbol, concept, or situation in a certain way." Osgood et al. (1957) indicated that an attitude is part of the semantic structure of the individual and may be defined as the projection from a point in multidimensional space onto the evaluate dimension. Jones and Gerard (1967) pointed out that an attitude is typically considered to involve categorization of an object along an evaluative dimension.

Sherief and Sherief (1967) indicated that attitude is a functional state of readiness which determines the organism to react in a characteristic way to certain stimuli or stimulus situations.

De Fluer and Westie (1965) defined attitude as a shorthand description for behavior. Cook and Selltiz (1964) regarded attitude as an underlying disposition that enters to the determination of one's beliefs, feeling, and approach-avoidance actions with respect to an object.

In spite of the wide variety of interpretations of the meaning of attitude, most of the above definitions of attitude had following substantial agreement:

1. Attitude is a predisposition to respond to an object or situation.
2. Attitude is persistent over time except substantial pressure has been added to the subject.

3. Attitude produces consistency in behavioral outcroppings.
4. Attitude has a directional quality.

Nature of attitude

Attitudes determine for each individual what he will see and hear, what he will think and what he will do; that means attitudes empirically guide the processing of information. Lingll and Ostrom (1981) pointed out that attitudes provide a framework in terms of which subsequent judgmental decisions are made. Generally, attitudes influence perceptions relevant to objects. Thus, an individual always guides perceptions of the object in the immediate situation when he or she encounters an attitude object.

Attitude consists of the following three components: affective, cognitive, and behavioral intentions component. The affective component is concerned with the emotional underpinning of these beliefs and represents the amount of positive or negative feeling that an individual has towards the attitude object. The cognitive component of attitude refers to the way in which the attitude object is perceived and conceptualized, and thus represents the individual's picture of the attitude object and his belief about it. The behavior intentions component is conceived as a consequence as well as a corollary of the other two components, and refers to the individual's intention to behavior in particular ways, or to his actual behavior, with regard to the attitude object.

Katy and Stotland (1959) classified attitude into the following five types: affective association, intellectual attitudes, actionoriented attitudes, balanced attitudes, and ego-defensive attitudes.

Theory and research of the development and change of attitude

Osgood et al. (1957) proposed a theory of attitude formation. In his dual-process theory, he divided the usual S-R paradigm into two stages. The first stage, called decoding, involves the association of sign with representational mediators. The second stage, called encoding, involves the association of mediational self-stimulation with overt instrumental sequences.

Weiss (1962) suggested that attitude may be developed by a process analogous to classical conditioning: conditional stimulus, unconditional stimulus, and unconditional response. Weiss also indicated that attitude may be acquired by a process analogous to instrumental learning: stimulus, response, delay, and reinforcement. Bandura and McDonald (1963) also indicated that attitude can be affected by imitative learning.

Another approach of the formation of the attitude is called operant learning. In this approach, attitude acquisition is based on the notion that attitudes consist simply of overt verbal behavior. Therefore, an attitude can be taught by varying reinforcement contingencies so as to shape behavior in the desired direction. Verplanck (1955) reported that subjects showed an increase in statement of opinion when reinforced by experimenters who either agreed with the subject or paraphrased the speaker's statement. Ekman (1958) and Centers (1963) also found attitude expression to be conditionable by operant procedures. But, Insko and Butzine (1967) pointed out that, although operant procedures have use for various issues in various contexts, verbal reinforcement is not equally effective in all situations.

In summary, research on the operant conditioning of attitudes indicated that the incidence of attitude statements can be increased by the use of verbal reinforcement. The directionality of the attitude can be altered and the effect of verbal reinforcement can be generalized to other attitudes and tasks.

Based on Tyler (1947), attitudes can be developed in people by the following four means: through assimilation from the environment, through emotional effects of certain kinds of experiences, through traumatic experiences, and through intellectual processes.

Several studies that involved the formation and change of attitude were discussed in the following. Fazio and Zanna (1981) indicated that attitudes formed through direct, behavioral experience with the attitude object have been found to be more predictive of later behavior than attitudes based on indirect, nonbehavioral experience. Cook (1979) examined whether different media with varying amount of informational cue was used to deliver a persuasive message to different learner groups would result in predicated attitude change. Cook's research was a pretest posttest control group design. He indicated that there was no significant difference in the attitude change between treatments. He also found that there were no significant interactions between any of learner characteristics, treatment and attitude change.

Klook's (1981) study was also an attempt to examine the use of media to change attitudes toward subject matter, but he divided the research subjects according to their level of field dependence and field independence. The result of this study indicated that the field independent subject who viewed the persuasive film had more attitude change than any other treatment or control group.

Berry (1983) studied the use of media to change attitude toward smoking. He used the randomized control group posttest only design. The result of this study reported that there was a significant change in attitude between treatments.

Stone (1984) found that film and slide with audiotape treatment group subjects scored significantly higher (more positive toward the disabled) on the attitude measure than the control group. He also stated that field dependent subjects scored significantly higher on the attitude measure than the field independent subject.

In summary, the theories and studies have shown that an attitude can be developed and/or changed through a well-designed and conducted instructional activity.

<u>Measurement of attitude</u>

Although attitude cannot be measured directly, it can be inferred by the following five methods:

1. Observation of overt behavior;
2. Performance of objective tasks which involve the attitudinal object or situation;
3. Reaction to or interpretation of partially structured stimuli which involve the attitudinal object or situation;

4. Physiological reactions to the attitudinal object or representations of it;

5. Self reports of individual's beliefs, feelings, and behaviors toward an attitudinal object or situation.

The existence of attitude and its strength can only be inferred from what is observable; therefore, one must choose behaviors which are acceptable as bases of inference. Traditionally, self-reported beliefs, feelings, and/or intention to act with respect to an object have been used as the primary basis of inference. Therefore, four self-reported attitude scaling procedures are discussed.

Thurstone's Equal-appearing Interval Scale The major purpose of Thurstone's Equal-appearing Interval Scale (1931) is to specify the location of each item on the evaluative dimension by assigning a scale value to the item. The first step in Thurstone's scaling is to collect a large pool of belief or intentional items related to some attitudinal object or situation. The major assumption of Thurstone's scaling is that the responses to items are expression of the person's attitude. More specifically, he made the assumption that different items may express different degree of favorableness or unfavorableness toward the attitudinal object or situation. The next step is to use judges to remove ambiguous and irrelevant items. Finally, the investigator can administer the scale to a sample of subjects and compute their attitude score by obtaining the median or mean scale value of all items endorsed.

Likert's Summated Rating Scale Collecting a large pool of beliefs or intention items, like the Thurstone scale, is also the first step in constructing a Likert Scale (1932). The next step is to eliminate neutral and ambiguous items. Then, the remaining items are administered directly to a sample of subjects, which represented the target population, by asking them to respond to each item on a five-point scale defined by the labels strongly agree, agree, neutral, disagree, and strongly disagree. An estimated attitude of each respondent is obtained by the following steps: First, responses to each item are scored from 1 to 5. Strong agreements with favorable items are given a score of 5, and strong disagreements with these items are given a score of 1. Scoring is reversed for unfavorable items. The person's attitude score is obtained by summing across all his item scores; that means the higher the score, the more favorable the attitude.

Guttman Scale The Guttman scaling procedure (1944) is designed to access the degree to which a given set of items form a cumulative scale. Items on a perfect cumulative scale are ordered along a single dimension. The property of a perfect Guttman scale is that when the person's location on the dimension is lower than that of the item, the probability that he will agree with the item is 0, conversely, when his location on the dimension is higher as or higher than that of the item, the probability he will agree with the item is 1. Therefore, the relation between total score and the response to any given items is step-shaped.

Osgood's Semantic Differential Scale Osgood et al. (1957) developed an attitude measuring scale called Semantic Differential Scale. This scale was intended to serve specifically as an index for measuring the representational mediation process. Subjects are provided with a series of concepts that are to be differentiated along seven-point scales defined by verbal opposites and judge the set of concepts along these adjective scales.

In general, the similarity of these procedures is that the resultant attitude score represents an individual location on a bipolar evaluative dimension vis-á-vis a given object. Beyond this fundamental similarity, there are several important differences between scales in terms of item characteristics. Semantic Differential Scales and Thurstone Scales are assumed to have equal-interval properties, but Guttman Scales and Likert scales are not. Another difference is that the traceline of a Guttman Scale is a step-shaped and the tracelines of a Thurstone Scale is an inverted U shape. The traceline of a Likert and a Semantic Differential Scale are linear. Finally, the items on a Guttman Scale are cumulative whereas items on the other scales are not.

Attitude and performance

The studies which investigated the relationship between attitude and performance were examined. Simonson (1979) pointed out that the most powerful rationale for the need to promote attitude positions in learners would be to demonstrate a direct relationship between attitude and achievement.

Loyd and Gressard (1984) indicated that positive attitudes increase the prospect for achievement in any academic endeavor, and negative attitude make achievement of competency less likely. Rushinek et al. (1985)

reported that "performance and attitude are closely related, although the relationship is not obvious." Atkinson (1974) indicated that high achievement motivation (attitude) is detrimental to performance.

Reid et al. (1973) reported that "no overall correlation between pretest-posttest attitude change and performance was observed." Lasoff (1981) also stated that "there was no linear relation between attitude and achievement scores."

From review of the literature, no consistent conclusion about the relationship between attitude and performance can be made. Further study is needed in this area.

Computer-Assisted Instruction

Several acronyms have been incorporated for teaching by computer. Those used most frequently are: Computer-Based Instruction (CBI), Computer-Managed Instruction (CMI), Computer-Assisted Learning (CAL), Computer-Assisted Teaching (CAT), and Computer-Assisted Instruction (CAI). CAI is the most popular and commonly used term in the literature on computerized instruction.

Type of CAI

Based on Thomas' (1979) study, there are four kinds of CAI. The first and most popular one is drill and practice. In drill and practice, the student receives a series of examples and practices in the area being taught; that means, students do not learn any new material but take practice in and reinforcement of previous learning. The second kind of CAI is the tutorial which provides new instructional material as well as the simple presentation of problems found in drill and practice. The next type of CAI is simulation. The computer simulation focuses on the interaction between the student and a computer-controlled model. Simulation can duplicate a real situation, allow students to assume the role of one factor in a simulated model, provide a system's reactions to a student's reaction, present new concepts or procedures, and review previously learned concepts or procedures. The last type of CAI is problem solving. The problem solving program is used to develop and improve students' problem solving abilities or learning strategies, to instruct the student to create a model or hypothesis, and to guide and direct students in developing models and hypotheses.

The characteristics of CAI

The individualized instruction in CAI is handled effectively and efficiently because of the characteristics of CAI.

The major characteristics of CAI are pacing, learner control, feedback, content and instructional adaptability. Pacing allows students to control and progress at their own rates. Learner control permits students control over pacing, content adaptability, and instructional adaptability based on their own background and learning style. Feedback provides comments on students' response to assist them in moving at a steady pace toward mastery of the objectives. Content adaptability permits varying the range and depth of the content of the lesson to meet students' different background. Instructional adaptability allows changing the method of presentation according to individual needs and performances.

<u>Effectiveness of CAI</u>

The review of literature concerning the effectiveness of CAI was divided into student achievement and attitude.

<u>Student achievement</u> Studies of the effectiveness of CAI on student achievement are discussed below.

Martin (1973) reported that CAI drill and practice in arithmetic to be relatively more effective for low ability students than for average or higher students. Lunetta and Blick (1973) showed that the student who used a computer simulation program in high school physical experiments learned more than the student who attended traditional laboratory experiments.

Fletcher and Atkinson (1972) indicated that students who received supplementary CAI in reading scored 0.6 grade level higher on a standardized test than students who received normal classroom instruction only. Edward et al. (1974) reported that CAI as a classroom supplement increased achievement scores while results were mixed when CAI was used as a substitute for regular instruction. Thomas (1979) reported that when CAI is used as a supplement to ongoing instruction it generally produces greater achievement regardless of the teaching strategy, computer system, testing method, or level of education.

Vanish and Boyd (1975) conducted an experiment using a posttest-only design to examine the effectiveness of CAI on 124 graduate nurses at the

George Washington University Medical Center. The results of this study indicated that there was no significant differences on performance measures between the experimental and control groups. King (1977) showed that using a CAI approach resulted in improved performance and a saving of time.

Huckabay et al. (1979) adopted a pretest and posttest design to examine the effectiveness of teaching clinical management by CAI. The result of this study showed that there were no significant differences between groups on measures of cognitive learning and transfer of learning to the clinical setting.

Saracho (1982) reported that students who used the CAI program had greater achievement gain than did students who participated in the regular classroom program. Conklin (1980) also found that the CAI group achieved significantly greater gains in learning than traditional group and control group.

Kulik and his associates' meta-analysis (1980) showed that CAI made small but significant achievement gain of college students. Kulik and his associates' meta-analysis (1983) also reported that CAI raised students' final scores by approximately 0.32 standard deviation at the secondary level. Kulik et al. (1985) further investigated the effect of CAI in elementary school using meta-analysis. They showed that CAI increased pupils' achievement scores about 0.47 standard deviation.

Groom (1982) conducted an experiment attempting to determine the effect of a combination of traditional and user-oriented interactive computer graphics instruction. Groom's research was a pretest-posttest control group design using engineering students as samples. The result of this study showed that the treatment group not only learned additional information but only used one-eighth of the time that the traditional method used.

A comparison of learning outcomes between drill and practice CAI and simulation CAI strategies was investigated by Dahl (1984). This study also examined the difference between field dependence and independence which involves the process of visual perception as well as problem solving. Dahl reported no significant differences on posttest achievement scores using these two strategies.

Woolsey (1986) conducted a study to determine the effectiveness of an adjunct CAI which employed two feedback structures comparison to traditional methods of presenting drafting concepts. A total of one hundred and five undergraduate students enrolled in Design Drafting 101 at the Indiana State University were used as the sample. The results of this study indicated that there was no significant difference on the achievement posttest scores between the control group, treatment group receiving the delayed feedback CAI, and the treatment group receiving immediate feedback CAI.

Student attitude   Review concerning the effect of CAI on student attitude are described below. Conklin (1980) conducted a study to examine the impact of CAI on learning and on attitudes in surgical nursing courses. A total of 34 baccalaureate students enrolled in the nursing program at the University of Calgary were randomly assigned to a CAI group, a traditional group, and a control group. The results of this study indicated that all groups increased in positive attitude toward CAI, but there were no significant differences between groups with respect to change in attitude scores.

Saracho (1982) examined the effects of a CAI program on basic skill achievement and attitude toward instruction of Spanish-speaking migrant children. The result of this study indicated that students who were in the CAI program had less favorable attitudes toward CAI than did students in the non-CAI program.

Rushinek et al. (1981) investigated the relationships between students' use of CAI and ratings of the computer facilities, the instructor, and the CAI tutorials relative to traditional instruction. The results of this study indicated that the attitude of the experimental group toward the computer was more positive than that of the control group. Rushinek et al. (1981) also reported that the use of CAI to supplement classroom instruction significantly improved students' attitude toward the instructor and the course.

Cavin et al. (1981) investigated whether college students' attitudes toward computers and chemistry would be affected by using CAI materials in the chemistry course. The results of this study showed that there was no change in attitude toward chemistry. The findings did indicate that the attitude of women toward computers was improved by using CAI.

Clement (1981) reported that student attitudes toward computer-based courses have been found to be positive among students in high school, community college, and college. Kulik et al. (1980, 1983) also reported that student attitudes were more positive toward computer and instruction after CAI at the secondary and college level.

Edward (1978) reported that using interactive CAI in a college mathematics class improved the students' attitudes toward mathematics relative to the students' attitudes in a non-CAI class.

Harris (1976) reported that there was no significant difference in attitude toward mathematics between CAI and non-CAI group students. Antista (1974) also reported that there was no significant difference in student attitudes between CAI and non-CAI groups.

Dunn and Wastler (1972) showed that CAI group students had more positive attitudes toward CAI and mathematics, but lower attitudes toward self and school.

CHAPTER III. METHODOLOGY

The primary purpose of this study was to identify specific student characteristics that correlate with achievement measures on selected drafting concepts under two teaching strategies. This chapter describes the population and samples, instrumentation and pilot test, experimental design, and analysis techniques used in this study.

Population and Samples

The population for this study consisted of students enrolled in the department of Freshman Engineering at Iowa State University.

The sample used in this study were those enrolled in section 3C, 3D, 4C, and 4D of Freshman Engineering 170 during the Fall semester, 1986 at Iowa State University. The students were randomly assigned to each section. The initial sample size was ninety-eight students but was reduced to eighty-nine students as a result of students withdrawing from the course. All four sections were taught by two co-instructors except in the experimental periods. Sections 3C and 3D met from 1:10 p.m. to 3:00 p.m. on Monday, Wednesday, and Friday. Sections 4C and 4D met the same day as that of Sections 3C and 3D, but they started from 3:00 p.m. till 5:00 p.m. The sections scheduled at the same time met in the same room with the same instructors.

Experimental Design

The experimental design for this study was a control group pretest-posttest design. The content of the treatment was the same as that described for the CAI package.

Students enrolled in sections 3C and 3D in the freshman engineering 170 in the Fall of 1986 were utilized as control subjects. Sections 4C and 4D served as experimental groups. Each section had 24 students. The experiment was conducted during the third and fourth week in the Fall semester of 1986. A pretest was administered on the first day of the experiment. The purpose of the pretest, which consisted of administering the precomputer attitude test, predrafting attitude test, predrafting achievement test, and a demographic information survey, was used to measure students' preattitudes toward computers and drafting, to collect demographic information, and to measure students' previous drafting achievement.

During the experiment, the control group used the same classroom and received traditional lectures. The experimental group received computer-assisted instruction using the CAI program via GIGI microcomputers attached to a VAX 11/785 computer. The experimental group students could run the CAI package as many times as they desired during the experimental period. The only prior knowledge experimental group students needed in order to use the CAI package was how to log on to the system. After the students ran the CAI package, the system automatically logged them off.

During the last day of the experiment, both groups took a posttest. The content of the posttest was the same as that of the pretest except that parallel drafting achievement items were used. The procedures for administration of the pre- and posttest are described in Appendix L. The time required to administer the pre- and posttests was fifty minutes.

Instrument Design and Pilot Test

Four instruments and one CAI program were developed in this study. A Demographic Information Questionnaire, a Computer Attitude Scale, a Drafting Attitude Scale, and two parallel Pretest and Posttest Drafting Achievement Tests were constructed as the primary instruments to obtain data relevant to the hypotheses of this study.

Demographic Information Questionnaire

One of the purposes of this study was to identify individuals' characteristics that correlated with their achievement and attitudes. It was hypothesized that the students' achievement and attitudes toward computers and toward subject matter would be related to their individual characteristics, former performance, and experiences. Student educational level, major, computer courses taken, drawing courses taken, and academic background were concepts used to develop an appropriate demographic questionnaire. A final version of the Demographic Information Questionnaire which consisted of 10 questions is shown in Appendix A.

Drafting Attitude Scale

Based on review of the literature, no existing drafting attitude scale was found. A drafting attitude item bank was constructed using items modified from the following attitude and anxiety scales: Fennema-Sherman's Mathematics Attitude Scale (Fennema and Sherman, 1976), Miller's Tool Anxiety Scales (Miller et al., 1983), Ahl's Public Attitudes Toward Computer Items (Ahl, 1976), Loyd and Gressard's Computer Attitude Scale (Loyd and Gressard, 1984), and Lin's Computer Anxiety Scale (Lin, 1985). A final version of the Drafting Attitude Scale (Appendix B) consisting of 20 items was developed from the item bank. The Drafting Attitude Scale consisted of 10 positive stated items and 10 negative stated items. A five-point Likert-type rating scale defined by the labels strongly agree, agree, neither, disagree, strongly disagree was used in this instrument.

Computer Attitude Scale

A Computer Attitude Scale (Appendix C) was developed from the same sources as the Drafting Attitude Scale and used the same type of rating scale and labels. The Computer Attitude Scale also consisted of 20 items; nine of them were positive stated items.

Pre- and Postdrafting Achievement Tests

Two parallel Pretest and Posttest Drafting Achievement Tests were developed (Appendixes D and E). Each test consists of 15 multiple choice questions and 15 sketch questions. The content of the tests include basic concepts of orthographic projection, transformation between pictorial and orthographic drawing, and missing line and view implementation in the multiple view drawing.

CAI program

A Computer-Assisted Instruction Package was developed to serve as the experimental treatment. The CAI program was written in the Digital Authoring Language (DAL). The objectives of this CAI package were to teach students:

1. to recognize the essential features of orthographic projection,

2. to understand the basic relationship of the principal projections,

3. to be able to interpret pictorial images of objects or conceptual ideas and produce correct images of objects or conceptual ideas and produce correct orthographic views of the objects,

4. to be able to identify correct solutions to problems.

This package also contained 20 randomly assigned questions for each student in the various drawing styles to give students a chance to test their degree of mastery of the material learned and provide immediate feedback, extra information, and/or praise based on the student response to each question.

The content of this package was basically the same as that of the material taught in the control group, but using different structure and approach. An example of content and questions in this package is shown in Appendix F.

Pilot test

A pilot test was conducted to test the preliminary instruments and CAI package. The subjects used in the pilot test were 33 students enrolled in the Industrial Education & Technology 120 course at Iowa State

University in the Spring of 1986.

In the pilot test, the same form of the drafting achievement test was used for both pre- and posttest. Due to the short time between testings, another parallel form was developed to serve as posttest in the field test. Minor modifications in the other instruments and the CAI package which included rewording, replacement of some questions, and switching the location of Demographic Information Sheet to protect student's privacy were implemented.

Method of Analysis

The Statistical Package for the Social Science (SPSS-X) and the Statistical Analysis System (SAS) which are installed in the AS/9160 mainframe computers were used to complete the analyses of this study.

Research variables

The research variables for which data were gathered include:

- Pretest achievement score (Pretest) and posttest achievement scores (Posttest) - measured by 30 orthographic questions
- Pretest computer attitude score (Precsatt) and posttest computer attitude score (Poscsatt) - measured by 20 computer attitude items.
- Pretest drafting attitude score (Predratt) and posttest drafting attitude score (Poscratt) - measured by 20 drafting attitude items.
- Number of semesters of drafting courses taken in high school and in college (Drawing)
- Number of semesters of computer courses taken in high school and college (CS)
- Educational level (Level) - freshman, sophomore, junior, or senior

- Collegiate major (Major) - chosen from a list of curriculum
- Self-reported American College Testing composite score (ACT)
- Self-reported college grade point average (GPA)
- Ownership of microcomputer (PC) 0 = no, 1 = yes

Descriptive analysis

A descriptive analysis including frequency, means, and standard deviation for each item as well as the characteristics of the sample was used to examine the distribution of the item responses of each instrument. An item analysis was employed to examine the difficulty and discrimination of each drafting achievement item. Descriptive analyses including frequencies, means, and correlations were used to describe the demographic variables. An Item-total Pearson Product-Moment correlation coefficient was employed to examine the contribution of each attitude item to the total attitude scores. A reliability analysis was used to determine internal consistency of each instrument.

Inferential analysis

A multiple-regression analysis method was used to identify the significant variables which contributed to prediction of the variance of posttest achievement scores, posttest drafting attitude scores, and posttest computer attitude scores. An analysis of covariance was applied to test the difference of posttest scores between the experimental group and the control group using variables identified in the previous regression analysis as covariates. A paired t-test was also employed to test the difference between pretest and posttest means.

In summary, the statistical procedures applied in this study included frequency analysis, Pearson product-moment correlation coefficient, multiple regression analysis, analysis of covariance, and paired t-test.

CHAPTER IV. RESULTS

The purpose of this study was to identify specific characteristics that correlate with achievement and attitudes measures on selected drafting concepts under two teaching strategies: traditional lecture and computer-assisted instruction. The research involved the study of these characteristics and their significance to three dependent variables: (1) student achievement in selected drafting concepts, (2) student attitude toward engineering drawing, and (3) student attitude toward computers. Student achievement was measured with a pair of parallel achievement instruments administered as pretest and posttest, while student attitude toward engineering drawing and computers were measured with a drawing attitude instrument and a computer attitude instrument, respectively. Student characteristics were obtained by using a demographic survey.

The results of the data analyses are presented in the following sections: (1) descriptions and analyses of sample characteristics, (2) analyses of instruments, and (3) tests of research hypotheses.

Descriptions and Analyses of Sample Characteristics

A total of eighty-nine subjects participated in the study. There were eighty-four males and five females. The sample included forty-six freshmen, thirty-six sophomores, and five juniors. The detail of the characteristics of samples are displayed in Appendix G.

Fifty-five students, or sixty-two percent of those who participated in this study, took one semester or more of mechanical drawing or architectural drawing courses during high school. Sixty-nine students, or seventy-seven percent, had at least one semester or more of computer courses in high school. Thirty-one students indicated that they owned a microcomputer. Other subjects' previous experiences included an average of 0.41 semester of drawing courses taken in college and 1.3 semesters of computer courses taken at the college level. The average college GPA of the subjects in the study was 2.69 and the average composite ACT score was 25.6.

Table 1 presents descriptive statistics for the dependent and independent variables. It includes the means, standard deviations, and the number of subjects on all tests for both control and experimental groups.

Table 2 presents correlation coefficients among all variables of the study. The postdrawing achievement (Posttest) was significantly correlated with predrawing achievement (Pretest), number of computer

Table 1. Descriptive statistics for dependent and independent variables by treatment group

Test	Maximum score	Control group			Experimental group		
		Mean	SD	N	Mean	SD	N
Pretest	30	16.73	4.60	45	16.52	3.90	44
Precsatt	5	3.74	0.65	45	3.71	0.53	44
Predratt	5	3.73	0.43	45	3.72	0.49	44
Posttest	30	19.24	4.84	45	20.61	3.81	44
Postcsatt	5	3.75	0.61	45	3.79	0.49	44
Posdratt	5	3.75	0.49	45	3.69	0.37	44

Table 2. Correlation coefficients for all measurements

Measure	Correlations 1	2	3	4	5	6	7
1. Posttest	1.000						
2. Pretest	.703***	1.000					
3. Sex	-.107	-.106	1.000				
4. Grade	-.192*	-.047	.027	1.000			
5. Major	-.004	.043	-.014	.157	1.000		
6. ACT	.097	.131	.010	-.131	.034	1.000	
7. GPA	.171	.033	.069	.048	.069	.277	1.000
8. Drawing1	.416***	.301***	-.166	-.203*	-.094	-.012	-.078
9. CS1	.003	.018	-.027	-.190*	-.221*	.096	-.071
10. Drawing2	.112	.094	-.082	.039	.031	-.181	-.036
11. CS2	.332***	.343***	.015	.289**	.130	.118	-.073
12. PC	-.143	-.170	.178*	.120	.099	-.150	.129
13. PREDRATT	.392***	.403***	-.242*	-.035	-.194*	.182	.053
14. PRESCATT	.288**	.321**	-.090	-.071	-.263**	.270**	.155
15. POSDRATT	.472***	.508***	-.152	-.056	-.073	.085	.010
16. POSCSATT	.318**	.292**	-.130	-.062	-.282**	.212*	.217*

*$p \leq .05$.

**$p \leq .01$.

***$p \leq .001$.

Correlations								
8	9	10	11	12	13	14	15	16
1.000								
-.096	1.000							
.208*	-.020	1.000						
.002	.057	.110	1.000					
-.039	-.206*	.170	.036	1.000				
.223*	.222*	.121	.297**	-.108	1.000			
.093	.406***	.009	.242*	-.355***	.587***	1.000		
.286**	.076	.166	.147	-.147	.717***	.539***	1.000	
.093	.313**	.017	.201*	-2.44*	.582***	.841***	.549***	1.000

courses taken in the college (CS2), preattitude toward drawing (Predratt), and preattitude toward computers (Precsatt).

Analysis of Instruments

The instruments administered to all research subjects in the study were the Engineering Drawing Achievement Pretest (Appendix D), Engineering Drawing Achievement Posttest (Appendix E), Attitude Toward Drawing Instrument (Appendix B), Attitude Toward Computers Instrument (Appendix C), and Demographic Information Questionnaire (Appendix A).

Table 3 contains the pretest item discrimination indices, item difficulties, and the test reliability coefficient alpha (Kuder-Richardson Formula 20 estimate of reliability). The alpha correlation coefficient of achievement pretest is 0.79.

Table 4 presents the achievement posttest item discrimination indices, item difficulties, and the test reliability coefficient alpha. The alpha reliability coefficient for the posttest was 0.83. The pretest-posttest correlation coefficient of 0.70 was significant.

The mean, standard deviation, and the frequency of responses of each item in the Attitudes Toward Drawing and Computers Instruments are displayed in Appendix H and Appendix I, respectively. The item scale values of the Drawing Attitude Instrument ranged from 3.34 to 4.45, while the item scale values of the Computers Instrument ranged from 2.78 to 4.51.

A correlation matrix among items was examined for each instrument. The correlations ranged from -0.10 to 0.68 among items of the drawing

Table 3. Pretest achievement test item analysis

Item number	Difficulty	Discrimination
1	0.87	0.27
2	0.51	0.14
3	0.50	0.30
4	0.76	0.23
5	0.98	0.04
6	0.92	0.17
7	0.94	0.30
8	0.97	0.39
9	0.95	0.40
10	0.92	0.32
11	0.91	0.37
12	0.87	0.38
13	0.96	0.36
14	0.91	0.23
15	0.86	0.25
16	0.25	0.53
17	0.19	0.56
18	0.53	0.43
19	0.01	0.32
20	0.28	0.62
21	0.34	0.39
22	0.34	0.52
23	0.24	0.54
24	0.33	0.57
25	0.28	0.42
26	0.51	0.50
27	0.22	0.55
28	0.05	0.40
29	0.04	0.40
30	0.17	0.54
	$\alpha = 0.79$	

Table 4. Posttest achievement test item analysis

Item Number	Difficulty	Discrimination
1	0.75	0.09
2	0.98	0.10
3	1.00	0.00
4	0.95	0.03
5	0.86	0.18
6	0.97	-0.10
7	0.99	0.31
8	0.97	0.27
9	0.99	0.31
10	0.98	0.34
11	0.99	0.34
12	0.97	0.20
13	0.98	0.34
14	0.80	0.52
15	1.00	0.00
16	0.66	0.67
17	0.41	0.67
18	0.77	0.57
19	0.42	0.56
20	0.26	0.61
21	0.29	0.37
22	0.42	0.68
23	0.35	0.69
24	0.10	0.34
25	0.54	0.52
26	0.12	0.49
27	0.42	0.66
28	0.40	0.62
29	0.07	0.40
30	0.58	0.48
	$\alpha = 0.83$	

attitude pretest and from -0.08 to 0.67 among items of the drawing attitude posttest. The correlation coefficient values ranged from -0.12 to 0.80 for the items of the computer attitude pretest and from -0.18 to 0.78 for the items of the computer attitude posttest.

Table 5. Reliability of attitude instruments

Measure	Inter-item mean correlation	Coefficient alpha
Attitude toward drawing		
Pretest	0.29	0.89
Posttest	0.29	0.89
Attitude toward computers		
Pretest	0.39	0.93
Posttest	0.37	0.92

Table 5 contains the mean inter-item correlation mean, and the coefficient alpha of the drawing and the computer attitude instruments. The reliability coefficients are 0.89 for the pretest and posttest drawing attitude instrument and 0.92 for the computer attitude instrument.

Tests of Research Hypothesis

In this section, the research hypotheses were examined for significance by use of various statistical analysis procedures including multiple regression analysis, F-test, and paired t-test.

The notation for the dependent and independent variables of the study are listed as follows:

$\hat{Y}_1$ = Posttest achievement (Posttest)

$\hat{Y}_2$ = Posttest attitude toward drawing (Postdratt)

$\hat{Y}_3$ = Posttest attitude toward computers (Poscatt)

X_1 = Treatment (0 = control group, 1 = experimental group)

X_2 = Self-reported American College Testing composite score (ACT)

X_3 = Pretest achievement (Pretest)

X_4 = Self-reported college grade point average (GPA)

X_5 = Number of semesters drawing courses taken in high school and in college (Drawing)

X_6 = Number of semesters computer courses taken in high school and in college (CS)

X_7 = Pretest attitude toward drawing (Predratt)

X_8 = Pretest attitude toward computers (Precsatt)

X_9 = Treatment x ACT

X_{10} = Treatment x GPA

X_{11} = Treatment x Pretest

X_{12} = Treatment x Predratt

X_{13} = Treatment x Precsatt

X_{14} = Treatment x Drawing

X_{15} = Treatment x CS

Hypothesis 1:

There will be no significant difference of posttest achievement scores between subjects exposed to traditional lecture and students exposed to computer-assisted instruction.

To test hypothesis 1, a comparison was made between the squared multiple correlation for a model containing the treatment variable (Full) and a model not containing treatment variable (Restricted).

Model #1 (Full):

$$\hat{Y}_1 = \Sigma\, B_i\, X_i + B_1\, X_1 + B_0 \quad \text{where } i = 2 \text{ to } 8$$

The results of the multiple regression analysis for the full model is presented in Table 6.

Model #2 (Restricted):

$$\hat{Y}_1 = \Sigma\, B_i\, X_i + B_0 \quad \text{where } i = 2 \text{ to } 8$$

In Table 7, the results of multiple regression analysis for restricted model is presented.

The calculation for the F-statistic needed to test hypothesis 1 is listed as follows:

Given:

$R_f^2 = 0.574208$ $\quad k_f = 8$ $\quad N = 66$

$R_r^2 = 0.521030$ $\quad k_r = 7$

Find:

$$F_{1,57} = \frac{(0.574208 - 0.521030)}{(1-0.574208)} \cdot \frac{57}{1} = 7.119*$$

Critical Value = 4.03 $(p < .05)$

Table 6. Results of multiple regression analysis for the dependent variable posttest achievement

Dependent variable	R square	Independent variable	Sum of squares[a]	F-value
Posttest ($\hat{Y}_1$)	0.574208	ACT (X_2)	4.216	0.46
		Pretest (X_3)	310.306	34.00***
		GPA (X_4)	25.536	2.80
		Drawing (X_5)	30.417	3.33
		CS (X_6)	5.132	0.56
		Predratt (X_7)	14.653	1.61
		Precsatt (X_8)	0.403	0.04
		Treatment (X_1)	64.980	7.12**

[a]Type III sum of squares.

**Significant at .01.

***Significant at .001.

Based on the F-statistic, it was concluded that there is a significant difference of posttest achievement scores between subjects exposed to traditional lecture and students exposed to computer-assisted instruction. Therefore, hypothesis 1 was rejected at .05 level.

Table 7. Results of multiple regression analysis for the dependent variable posttest achievement

Dependent variable	R square	Independent variable	Sum of squares[a]	F-value
Posttest ($\hat{Y}_1$)	0.521030	ACT (X_2)	3.611	0.36
		Pretest (X_3)	296.892	29.42***
		GPA (X_4)	25.150	2.49
		Drawing (X_5)	25.088	2.49
		CS (X_6)	4.191	0.42
		Predratt (X_7)	16.357	1.62
		Precsatt (X_8)	0.173	0.02

[a]Type III sum of squares.

***Significant at .001.

The effect of interaction between aptitude and treatment, between attitude and treatment, and between previous experience and treatment in relation to student's score on the postdrawing achievement are stated in the second, third, and fourth hypotheses, respectively.

Hypothesis 2:

There will be no significant interaction between the treatment and subject aptitudes in relation to subject's score on the postdrawing achievement test.

The same statistical analysis procedures and logic as for testing hypothesis 1 were applied to test hypothesis 2.

The previous full model becomes the new restricted model and the new full model includes the second order interactions between treatment and aptitude.

Model #2 (Restricted):

$$\hat{Y}_1 = \Sigma\, B_i\, X_i + B_0 \quad \text{where } i = 1 \text{ to } 8$$

Model #3 (Full):

$$\hat{Y}_1 = \Sigma\, B_i\, X_i + \quad B_j\, X_j + B_0 \quad \text{where } i = 1 \text{ to } 8 \text{ and } j = 9 \text{ to } 11$$

The results of the multiple regression of the full model are presented in Table 8.

The following is the calculation for the F-statistics to test hypothesis 2.

Given:

$R_f^2 = 0.635514 \qquad k_f = 11 \qquad N = 66$

$R_r^2 = 0.574208 \qquad k_r = 8$

Find:

$$F_{3,54} = \frac{(0.635514 - 0.574208)}{(1 - 0.635514)} \cdot \frac{54}{3} = 3.0276*$$

Table 8. Results of multiple regression analysis for the dependent variable posttest achievement

Dependent variable	R square	Independent variable	Sum of squares[a]	F-value
Posttest ($\hat{Y}_1$)	0.635514	ACT (X_2)	0.171	2.81
		Pretest (X_3)	192.144	23.30***
		GPA (X_4)	28.510	3.46
		Drawing (X_5)	25.780	3.13
		CS (X_6)	2.327	0.28
		Predratt (X_7)	31.205	3.78
		Precsatt (X_8)	1.883	0.23
		Treatment (X_1)	23.181	2.81
		Treatment x ACT (X_9)	3.036	0.37
		Treatment x GPA (X_{10})	6.867	0.83
		Treatment x Pretest (X_{11})	59.938	7.27**

[a]Type III sum of squares.

**Significant at .01.

***Significant at .001.

Critical value = 2.78 $(p < .05)$

Based on the above F-statistics, the hypothesis 2 is rejected at .05 level. Therefore, it was concluded that there are significant interactions between treatment and aptitude in relation to the subject's score on the postdrawing achievement test. A significant interaction occurred between treatment and predrawing achievement test.

Hypothesis 3:

There will be no significant interaction between the treatment and pretest attitude in relation to subject's score on the postdrawing achievement test.

Hypothesis 4:

There will be no significant interaction between the treatment and previous experiences in relation to subject's score on the postdrawing achievement test.

To test hypotheses 3 and 4, the previous full model becomes the new restricted model and the full model includes the interactions between treatment and attitude as well as the interactions between treatment and previous experiences.

Model #3 (Restricted):

$$\hat{Y}_1 = \Sigma B_i X_i + B_0 \quad \text{where } i = 1 \text{ to } 11$$

Model #4 (Full):

$$\hat{Y}_1 = \Sigma B_i X_i + \quad B_j X_j + B_0 \quad \text{where } i = 1 \text{ to } 11 \text{ and } j = 12 \text{ to } 15$$

The results of the multiple regression analysis of the full model are presented in Table 9.

Given:

$$R_f^2 = 0.677866 \qquad k_f = 15 \qquad N = 66$$

$$R_r^2 = 0.635514 \qquad k_r = 11$$

Find:

$$F_{(4,50)} = \frac{(0.677866 - 0.635514)}{(1 - 0.677866)} \cdot \frac{50}{4} = 1.6434$$

Critical Value = 2.57 $(p < .05)$

This indicated that the effect of the interaction between treatment and attitudes and the effect of the interaction between treatment and previous experiences do not contribute significantly to post drawing achievement test scores. Hence, the result failed to provide necessary evidence to reject hypotheses 3 and 4 at .05 level.

Hypotheses 5, 6, 7, and 8 are stated in the same way as hypotheses 1, 2, 3, and 4, respectively, and use the same independent variables; however, the dependent variable for hypotheses 5, 6, 7, and 8 is the posttest scores of attitude toward computers.

Hypothesis 5:

There will be no significant difference of posttest scores of attitude toward computers between subjects exposed to traditional lecture and computer-assisted instruction.

Table 9. Results of multiple regression analysis for the dependent variable posttest achievement

Dependent variable	R square	Independent variable	Sum of squares[a]	F-value
Posttest ($\hat{Y}_1$)	0.677866	ACT (X_2)	0.715	0.09
		Pretest (X_3)	221.973	28.20***
		GPA (X_4)	32.536	4.13*
		Drawing (X_5)	26.967	3.43
		CS (X_6)	7.500	0.95
		Predratt (X_7)	21.313	2.71
		Precsatt (X_8)	12.977	1.65
		Treatment (X_1)	49.611	6.30*
		Treatment x ACT (X_9)	0.127	0.02
		Treatment x GPA (X_{10})	5.779	0.73
		Treatment x Pretest (X_{11})	15.930	2.02
		Treatment x Predratt (X_{12})	19.489	2.48
		Treatment x Precsatt (X_{13})	8.333	1.12
		Treatment x Drawing (X_{14})	6.984	0.89
		Treatment x CS (X_{15})	0.186	0.02

[a]Type III sum of squares.

*Significant at .05.

***Significant at .001.

To test hypothesis 5, a comparison similar to the one for hypothesis one was made between the multiple R square of a model containing the treatment variable (Full) and a model not containing it (Restricted).

Model #5 (Full):

$$\hat{Y}_2 = B_i X_i + B_1 X_1 + B_0 \quad \text{where } i = 2 \text{ to } 8$$

Table 10 presents the results of the multiple regression analysis for the full model.

Model #6 (Restricted);

$$\hat{Y}_2 = B_i X_i + B_0 \quad \text{where } i = 2 \text{ to } 8$$

The results of the multiple regression analysis for the restricted model are presented in Table 11.

Based on the critical value of 4.03, there is no significant difference of the posttest scores of attitude toward computers between subjects exposed to traditional lecture and students exposed to computer-assisted instruction. Thus, hypothesis 5 failed to be rejected at the .05 level.

Hypothesis 6:

There will be no significant interaction between the treatment and aptitude in relation to subject's posttest score on the attitude toward computers.

Table 10. Results of multiple regression analysis for the dependent variable posttest score of attitude toward computers (Poscsatt)

Dependent variable	R square	Independent variable	Sum of squares[a]	F-value
Poscsatt ($\hat{Y}_2$)	0.733088	ACT (X_2)	0.015	0.16
		Pretest (X_3)	0.004	0.05
		GPA (X_4)	0.228	2.42
		Drawing (X_5)	0.001	0.002
		CS (X_6)	0.000	0.00
		Predratt (X_7)	0.150	1.60
		Precsatt (X_8)	6.763	71.87***
		Treatment (X_1)	0.063	0.67

[a]Type III sum of squares.

***Significant at .001.

Hypothesis 7:

There will be no significant interaction between the treatment and pretest attitude in relation to subject's posttest score on the attitude toward computers.

Table 11. Results of multiple regression analysis for the dependent variable posttest score of attitude toward computers (Poscsatt)

Dependent variable	R square	Independent variable	Sum of squares[a]	F-value
Poscatt ($\hat{Y}_2$)	0.729944	ACT (X_2)	0.014	0.15
		Pretest (X_3)	0.003	0.03
		GPA (X_4)	0.227	2.43
		Drawing (X_5)	0.003	0.03
		CS (X_6)	0.000	0.00
		Predratt (X_7)	0.156	1.66
		Precsatt (X_8)	6.804	72.71***

[a]Type III sum of squares.

***Significant at .001.

Hypothesis 8:

There will be no significant interaction between the treatment and previous experiences in relation to subject's posttest score on the attitude toward computers.

To test hypotheses 6, 7, and 8, the previous full model serves as a new restricted model and the new full model includes all the second order interactions mentioned in the above hypotheses.

Model #6 (Restricted):

$$\hat{Y}_2 = \Sigma\, B_i\, X_i + B_0 \quad \text{where } i = 1 \text{ to } 8$$

Model #7 (Full):

$$\hat{Y}_2 = \Sigma\, B_i\, X_i + \quad B_j\, X_j + B_0 \quad \text{where } i = 1 \text{ to } 8 \text{ and } j = 9 \text{ to } 15$$

The results of the multiple regression analysis for the full model are presented in Table 12.

Based on the critical value of 2.21, there is no significant interactions between treatment and aptitude, attitude, and previous experiences in relation to subject's posttest score on the attitude toward computers. Hence, hypotheses 6, 7, and 8 failed to be rejected at the .05 level.

Hypotheses 9, 10, 11, and 12 are stated the same way as hypotheses 1, 2, 3, and 4, respectively, and use the same independent variables as hypotheses 1, 2, 3, and 4, respectively; however, the dependent variable is posttest score of attitude toward drawing.

Hypothesis 9:

There will be no significant difference of posttest score of attitude toward drawing between subjects exposed to traditional lecture and students exposed to computer-assisted instruction.

To test this hypothesis, a comparison, which is similar to one for test hypothesis 1, was made between the multiple R square of a model containing the treatment variable (Full) and a model not containing treat-

Table 12. Results of multiple regression analysis for the dependent variable posttest score of attitude toward computers (Poscsatt)

Dependent variable	R square	Independent variable	Sum of squares[a]	F-value
Poscsatt ($\hat{Y}_2$)	0.757061	ACT (X_2)	0.001	0.01
		Pretest (X_3)	0.027	0.28
		GPA (X_4)	0.225	2.30
		Drawing (X_5)	0.007	0.07
		CS (X_6)	0.010	0.10
		Predratt (X_7)	0.211	2.16
		Precsatt (X_8)	4.757	48.71***
		Treatment (X_1)	0.003	0.03
		Treatment x ACT (X_9)	0.130	0.33
		Treatment x GPA (X_{10})	0.032	0.33
		Treatment x Pretest (X_{11})	0.248	2.54
		Treatment x Predratt (X_{12})	0.012	0.12
		Treatment x Precsatt (X_{13})	0.001	0.01
		Treatment x Drawing (X_{14})	0.042	0.43
		Treatment x CS (X_{15})	0.001	0.01

[a]Type III sum of squares.

***Significant at .001.

ment (Restricted);

Model #8 (Full):

$$\hat{Y}_3 = B_i X_i + B_1 X_1 + B_0 \quad \text{where } i = 2 \text{ to } 8$$

The results of the multiple regression analysis for the Full model are presented in Table 13.

Model #9 (Restricted):

$$\hat{Y}_3 = B_i X_i + B_0 \quad \text{where } i = 2 \text{ to } 8$$

The results of multiple regression analysis for the restricted model are presented in Table 14.

Based on the critical value of 4.03, there is no significant difference of posttest score of attitude toward drawing between subjects exposed to traditional lecture and students exposed to computer-assisted instruction. Thus, hypothesis 9 failed to be rejected at .05 level.

Hypothesis 10:

There will be no significant interaction between the treatment and aptitude in relation to subject's posttest score on the attitude toward drawing.

Hypothesis 11:

There will be no significant interaction between the treatment and pretest attitude in relation to subject's posttest score on the attitude toward drawing.

Table 13. Results of multiple regression analysis for the dependent variable posttest score of attitude toward drawing (Posdratt)

Dependent variable	R square	Independent variable	Sum of squares[a]	F-value
Posdratt ($\hat{Y}_3$)	0.638236	ACT (X_2)	0.063	0.86
		Pretest (X_3)	0.682	9.24**
		GPA (X_4)	0.037	0.50
		Drawing (X_5)	0.004	0.05
		CS (X_6)	0.516	7.00**
		Predratt (X_7)	2.166	29.36***
		Precsatt (X_8)	0.544	7.38**

[a]Type III sum of squares.

**Significant at .01.

***Significant at .001.

Hypothesis 12:

There will be no significant interaction between the treatment and previous experience in relation to posttest score on the attitude toward drawing.

The same statistical analysis procedures and logic have been used to test these hypotheses, however, there were no significant interaction

Table 14. Results of multiple regression analysis for the dependent variable posttest score of attitude toward drawing (Posdratt)

Dependent variable	R square	Independent variable	Sum of squares[a]	F-value
Posdratt ($\hat{Y}_3$)	0.638838	ACT (X_2)	0.063	0.83
		Pretest (X_3)	0.673	8.87**
		GPA (X_4)	0.037	0.49
		Drawing (X_5)	0.003	0.04
		CS (X_6)	0.519	6.93**
		Predratt (X_7)	2.17	28.96***
		Precsatt (X_8)	0.547	7.30**
		Treatment (X_1)	0.007	0.09

[a]Type III sum of squares.

**Significant at .01.

***Significant at .001.

between the treatment and aptitude, attitude, and previous experiences. Hence, hypotheses 10, 11, and 12 failed to be rejected at .05 level. The results of multiple regression analysis are presented in Table 15.

Hypothesis 13:

There will be no significant change in scores of attitude toward

Table 15. Results of multiple regression analysis for dependent variable posttest score of attitude toward drawing (Posdratt)

Dependent variable	R square	Independent variable	Sum of squares[a]	F-value
Posdratt ($\hat{Y}_3$)	0.662267	ACT (X_2)	0.065	0.82
		Pretest (X_3)	0.470	5.88*
		GPA (X_4)	0.026	0.32
		Drawing (X_5)	0.017	0.21
		CS (X_6)	0.569	7.12**
		Predratt (X_7)	2.063	25.82***
		Precsatt (X_8)	0.449	5.62*
		Treatment (X_9)	0.002	0.03
		Treatment x ACT (X_9)	0.064	0.80
		Treatment x GPA (X_{10})	0.036	0.45
		Treatment x Pretest (X_{11})	0.010	0.13
		Treatment x Predratt (X_{12})	0.134	1.68
		Treatment x precsatt (X_{13})	0.060	0.74
		Treatment x Drawing (X_{14})	0.107	1.34
		Treatment x CS (X_{15})	0.004	0.005

[a]Type III sum of squares.
*Significant at .05.
**Significant at .01.
***Significant at .001.

graphic subject matter obtained prior to and following instruction under the two treatment modes.

The results of the paired t-test are presented in Table 16. Hypothesis 13 cannot be rejected based on this analysis. Therefore, it can be concluded that there is no significant change in scores of attitude toward graphic subject matter obtained prior to and following instruction under the two treatment modes.

Hypothesis 14:

There will be no significant difference between pre- and postscores measuring the attitude toward the use of computers under two treatment modes.

In Table 17, the results of paired t-test are presented. By examining Table 17, the posttest scores of the attitude toward computers is significantly higher than the pretest scores of the attitude toward computers in the experimental group. However, there is no significant difference between pre- and postscores of the attitude toward computers in the control group. This analysis did not contain the additional controls utilized in hypothesis 5 which found no differences between the experimental and control groups on posttest attitude scores.

Table 16. Paired t-test for attitude toward drawing

Mode	Variable	Number of case	Mean	SD	T
Control group	Posttest	45	3.75	0.49	0.40 ns
	Pretest		3.73	0.43	
Experimental group	Posttest	44	3.69	0.37	-0.88 ns
	Pretest		3.72	0.49	

Table 17. Paired t-test for attitude toward computers

Mode	Variable	Number of case	Mean	SD	T
Control group	Posttest	45	3.75	0.61	0.12 ns
	Pretest		3.74	0.65	
Experimental group	Posttest	44	3.79	0.49	1.99*
	Pretest		3.71	0.53	

*Significant at .05.

CHAPTER V. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary and Conclusions

The problem of this study was to examine the effect on the achievement of selected drafting concepts of the interaction between student characteristics and two teaching strategies: traditional lecture and computer-assisted instruction.

The purposes of this study were to identify specific student characteristics that correlate with achievement measures on selected drafting concepts under two teaching strategies. The research involved the study of these characteristics and their significance to three dependent variables: (1) student achievement in a selected drafting concept, (2) student attitude toward engineering drawing, and (3) student attitude toward computers.

The subjects for this study consisted of ninety-eight college level students enrolled in the Freshman Engineering 170 during the Fall semester, 1986 at Iowa State University. Freshman Engineering 170 is a course consisting of the integration of fundamental graphics, computer graphics, and engineering design. The graphics coverage include orthographic projection, pictorials, section, dimensioning, and three dimensional geometry.

The experimental design for this study was an experimental and control group pretest-posttest design. A pretest was administered to all subjects on the first day of the experimental period. The purpose of the pretest, which consisted of administering the pre-computer attitude test, predrafting attitude test, predrafting achievement test, and a demographic survey, was to measure students' preattitudes toward computers and drafting, to collect demographic information, and to measure students' previous drafting achievement. Treatments were applied for two weeks which is the normal period of time used during the semester for presenting the concepts of orthographic projection. During the last day of the experiment, both groups took a posttest. The content of the posttest was the same as that of the pretest except that parallel drafting achievement items were used. The reliability coefficient of instruments ranged from 0.79 to 0.93.

Fourteen hypotheses were identified and tested. Hypothesis 1 tested the difference of posttest achievement scores between subjects exposed to two different teaching strategies. Hypothesis 2 tested the interaction between the treatment and subject aptitudes in relation to subject's scores on the postdrawing achievement test. Hypothesis 3 tested the interaction between treatment and attitude in relation to subject's scores on the postdrawing achievement test. Hypothesis 4 tested the interaction between treatment and previous experiences in relation to subject's score on the postdrawing achievement test. The hypotheses 5, 6, 7, and 8 were stated in the same way as hypotheses 1, 2, 3, and 4, respectively, and used the same independent variables. The dependent variable for these hypotheses were the posttest scores of attitude toward computers. Hypotheses 9, 10, 11, and 12 were also stated in the same way as hypotheses 1, 2, 3, and 4, respectively, and used the same independent variables. The dependent variable was posttest scores of attitude toward drawing. Hypothesis 13 tested the change in scores of attitude toward graphic subject matter obtained prior and following instruction under the two treatment modes. The last hypothesis tested the difference between pre- and postscores measuring the attitude toward the use of computers under two teaching strategies.

The results of testing the hypotheses were:

1. There was a significant difference of posttest achievement scores between subjects exposed to traditional lecture and students exposed to computer-assisted instruction. Students exposed to CAI achieved higher scores.

2. There were significant interactions between the treatment and aptitude in relation to subject's score on the postdrawing achievement test. A significant interaction occurred between treatment and the predrawing achievement test. On the pretest, the mean scores of experimental group subjects was lower than that of the control group. On the posttest, the mean of experimental group scores was significantly higher than that of the control group.

3. There was no significant interaction between the treatment and pretest attitude in relation to subject's score on the postdrawing achievement test.

4. There was no significant interaction between the treatment and previous experiences in relation to subject's score on the postdrawing achievement test.

5. There was no significant difference of posttest scores of attitude toward computers between subjects exposed to traditional lecture and computer-assisted instruction.

6. There was no significant interaction between the treatment and aptitude in relation to subject's posttest score on the attitude toward computers.

7. There was no significant interaction between the treatment and pretest attitude in relation to subject's posttest score on the attitude toward computers.

8. There was no significant interaction between the treatment and previous experiences in relation to subject's posttest score on the attitude toward computers.

9. There was no significant difference of posttest score of attitude toward drawing between subjects exposed to traditional lecture and students exposed to computer-assisted instruction.

10. There was no significant interaction between the treatment and aptitude in relation to subject's posttest score on the attitude toward drawing.

11. There was no significant interaction between the treatment and pretest attitude in relation to subject's posttest score on the attitude toward drawing.

12. There was no significant interaction between the treatment and previous experience in relation to posttest score on attitude toward drawing.

13. There was no significant change in scores of attitude toward graphic subject matter obtained prior to and following instruction under the two treatment modes.

14. The posttest scores of the attitude toward computers was significantly higher than the pretest scores in the experimental group. However, there was no significant difference between pre- and postscores of the attitude toward computers in the control group.

Discussion

Throughout this study, it was found that the subjects receiving the computer-assisted instruction achieved significantly greater gains in learning of orthographic projection. This supports the finding of Groom (1982), King (1977), Saracho (1982), Kulik et al. (1980), and Conklin (1980). Generally, CAI can be effective in improving student achievement. Indirect observation suggested that the students in the experimental group used less time to master material and finish assignments. From the results of this study, one can expect that CAI can contribute to instructional efficiency and be more cost-effective than conventional instruction. Unfortunately, very little data exists in the literature. Often, what does exist has limited application. For example, many of the early investigations of cost factors related to the use of CAI discussed only the cost of development, implementation, and maintenance of CAI package. They did not consider student achievement relative to the costs of instructional alternatives. Therefore, the study of the cost-effectiveness of CAI, not just the study of cost-feasibility, should be encouraged. A replication of this study with an extension of treatment time and with a different population is appropriate.

This study showed that aptitude, as determined by predrawing achievement scores (Pretest), did significantly interact in treatment. This finding is in agreement with the previously reported studies concerning aptitude and academic achievement (Edward et al., 1974) which found an interaction when CAI was used.

The results of this study failed to demonstrate an instructional interaction between academic achievement and attitude. This result is in agreement with what were reported by Reid et al. (1973), Rushinek et al., (1981), and Clement (1981).

The results of this study also failed to demonstrate any interaction between treatment and aptitude, or between treatment and attitude, or between treatment and previous experience in relation to subject's posttest scores on the attitude toward computers and toward drawing subject matter. One of the reasons for these findings may have been the small sample size. Cronbach and Snow (1977) suggested that in order to obtain adequate statistical power, the researcher conducting aptitude-treatment interaction studies should use 100 subjects per treatment group. In this study, the number of subjects in each group was approximately one-third the number suggested by Cronbach and Snow. In order to study the interaction between student characteristics and teaching strategies, other elements of aptitude, attitude, and previous experience should be identified. For example, spatial ability or visual perception may be important factors that affect achievement of students in engineering drawing. Gender, personality, and style of learning may be other sources that will affect student achievement and attitude.

Recommendation

It would appear, as a result of this study, achievement in orthographic projection for students in the experimental group was significantly higher than that in the control group. CAI as an instructional methodology is relatively expensive and time consuming to develop. However, more research in this area is needed and should be encouraged by persons in the engineering drawing community. The areas recommended for further study are:

1. An expanded study is recommended by increasing the treatment period and the content covered by the CAI program.

2. A similar study is recommended by including the measurement of spatial ability and/or visual perception in the pretest for further reducing the unexplained variance.

3. Further research should be undertaken to determine how demographic variables and other factors relate to the achievement and attitude in other technical areas of study.

4. Further research should be conducted to identify relationships between student characteristics, achievement, attitudes, and other factors relative to the development of engineering drawing skill and experience.

5. Further research should be conducted to determine how computer-assisted instruction can best be utilized in engineering drawing at the secondary level.

6. Research should be conducted to study the possibility of combining computer-assisted instruction, computer graphic packages, and computer-aided design packages in the engineering drawing and design course.

7. Research should be undertaken to identify methods of improving the utilization of teacher resources in the classroom while using CAI at the secondary and postsecondary levels.

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This study would not have been possible without the guidance and assistance given by many people. Foremost, I would like to sincerely thank Dr. William G. Miller, my major advisor, for his guidance, assistance, consideration, and support during the pursuit of graduate study at Iowa State University. He has provided insight and wisdom in the area of industrial education and technology and computer science which will guide and strengthen my professional career. Thanks are also extended to the members of my graduate committee, Dr. Trevor Howe, Dr. William Wolansky, Dr. John Dugger, and Dr. Robert Lambert, for their assistance in completion of my graduate program.

I would also like to thank the faculty and students of Freshman Engineering 170 for their participation in this study. Dr. Cletus Mercier deserves a special acknowledgment for his assistance and coordination provided to insure that this study was successfully implemented.

My sincere gratitude is expressed to my wife, Susan, and beloved son, Vincent, for their understanding, support, encouragement, and patience throughout the study.

The deepest gratitude is expressed to my parents, Mr. and Mrs. Shun-Jin Tai, for their encouragement, understanding and confidence over the years to sustain my working toward this personal goal.

APPENDIX A. DEMOGRAPHIC INFORMATION QUESTIONNAIRE

User name: ____________________

Demographic Information

(All response will be kept in strict confidence.)

Please answer every following question with an "x" or response in the space provided.

Username: WGX____________

1. What is your sex?
   ( ) A. male ( ) B. female

2. What is your current educational status?
   ( ) A. freshman ( ) B. sophomore ( ) C. junior ( ) D. senior

3. What is your major? ____________________

4. What is your ACT composite score? ____________

5. What is your college GPA? ____________

6. How many semesters of mechanical drawing and architectural drawing did you have in grades 9 through 12? ______________

7. How many semesters of computer courses did you have in grades 9 through 12? ______________

8. How many semester credits of mechanical drawing and architectural drawing have you had in college? ______________

9. How many semester credits of computer science courses have you had in college? ______________

10. Do you have a micro-computer at home?
    ( ) A. yes ( ) B. no

APPENDIX B. ENGINEERING DRAWING ATTITUDE SCALE

User name: _______________

Engineering Drawing Attitude Scale

Directions:

This instrument is designed to provide you an opportunity to express your feeling toward engineering drawing. There are neither "correct" nor "incorrect" response for each statement. You are simply asked to indicate how strongly you agree or disagree with the ideas expressed in each statement. Therefore, please do not hesitate to respond frankly and mark down your answer.

	Strongly agree	Agree	Neither	Disagree	Strongly disagree
1. When an engineering graphics problem arises that I can't immediately solve, I stick with it until I have the solution.	SA	A	N	D	SD
2. I don't understand how some people can spend so much time on engineering graphics and seem to enjoy it.	SA	A	N	D	SD
3. It would not bother me at all to take more engineering graphics courses.	SA	A	N	D	SD
4. Engineering graphics is a worthwhile and necessary subject.	SA	A	N	D	SD
5. Taking engineering graphics is a waste of time.	SA	A	N	D	SD
6. Engineering graphics usually make me feel uncomfortable and nervous.	SA	A	N	D	SD
7. I feel confident about my ability to deal with engineering graphics.	SA	A	N	D	SD
8. For some reason even though I study, engineering graphics seems unusually hard for me.	SA	A	N	D	SD
9. I think I could handle more difficult engineering graphics.	SA	A	N	D	SD
10. I am not the type of person to do well in the engineering graphics.	SA	A	N	D	SD

	Strongly agree	Agree	Neither	Disagree	Strongly disagree
11. I am sure I can learn engineering graphics.	SA	A	N	D	SD
12. I don't think I could do advanced engineering graphics.	SA	A	N	D	SD
13. Engineering graphics doesn't scare me at all.	SA	A	N	D	SD
14. Engineering graphics makes me feel uneasy and confused.	SA	A	N	D	SD
15. I haven't usually worried about being able to solve engineering graphics problems.	SA	A	N	D	SD
16. I get a sinking feeling when I think of trying hard engineering graphics problems.	SA	A	N	D	SD
17. Engineering graphics is enjoyable and stimulating to me.	SA	A	N	D	SD
18. The challenge of engineering graphics problems does not appeal to me.	SA	A	N	D	SD
19. When a question is left unanswered in engineering graphics class, I continue to think about it afterward.	SA	A	N	D	SD
20. I do as little work in engineering graphics as possible.	SA	A	N	D	SD

APPENDIX C. COMPUTER ATTITUDE SCALE

User name: ________________

Computer Attitude Scale

Directions:

This instrument is designed to provide you an opportunity to express your feeling toward computers. There are neither "correct" nor "incorrect" response for each statement. You are simply asked to indicate how strongly you agree or disagree with the ideas expressed in each statement. Therefore, please do not hesitate to response frankly and mark down your answer.

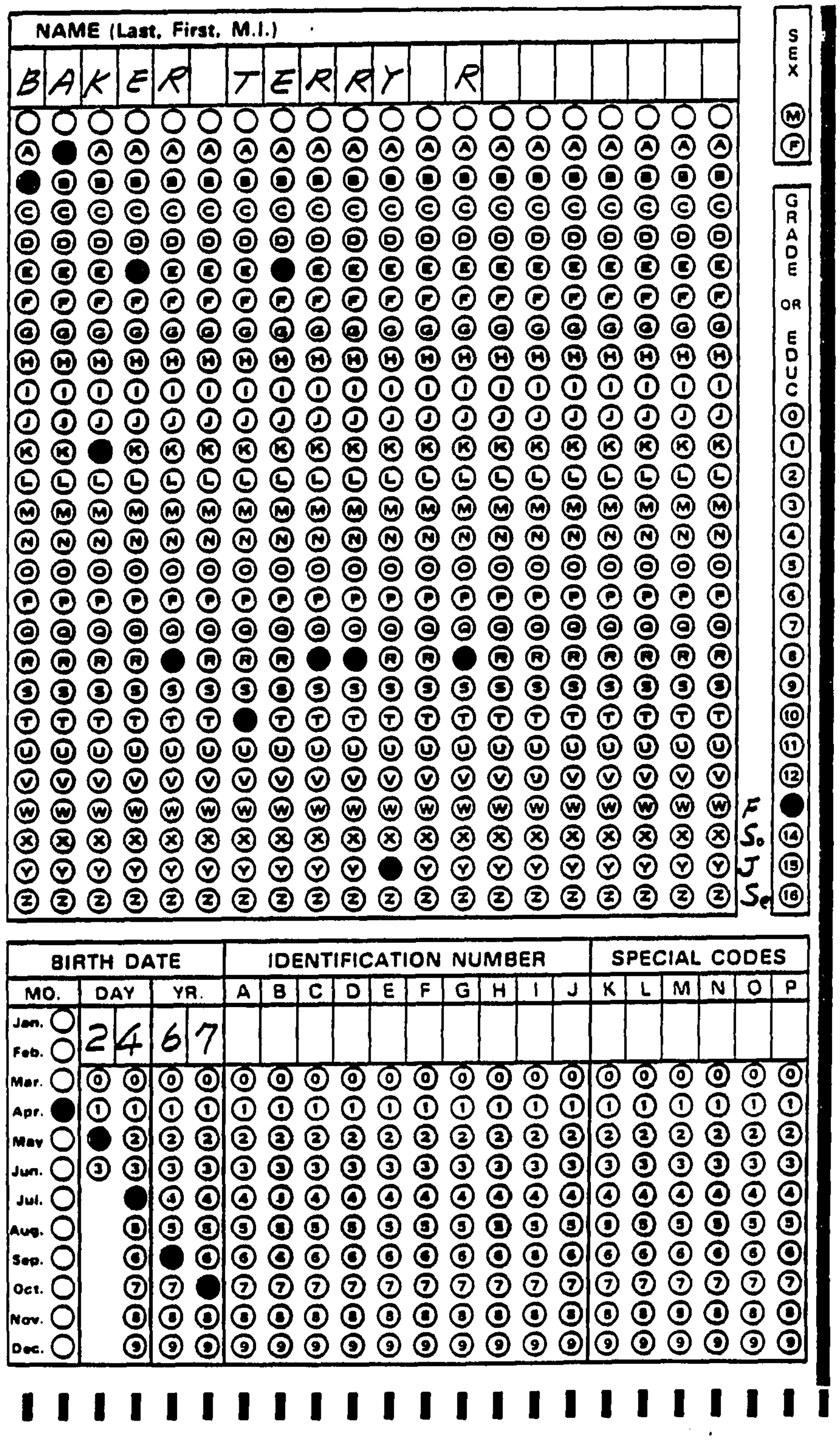
		Strongly agree	Agree	Neither	Disagree	Strongly disagree
21.	Computers do not scare me at all.	SA	A	N	D	SD
22.	I prefer to stay away from computers.	SA	A	N	D	SD
23.	I think working with omputers would be enjoyable and stimulating.	SA	A	N	D	SD
24.	Figuring out computer problems does not appeal to me.	SA	A	N	D	SD
25.	Computers are fascinating and fun.	SA	A	N	D	SD
26.	Working with a computer would make me very nervous.	SA	A	N	D	SD
27.	I do enjoy talking with others about computers.	SA	A	N	D	SD
28.	I will do as little work with computers as possible.	SA	A	N	D	SD
29.	I feel confident about my ability to deal with computers.	SA	A	N	D	SD
30.	I get a sinking feeling when I think of trying to use a computer.	SA	A	N	D	SD
31.	I would like working with computers.	SA	A	N	D	SD

	Strongly agree	Agree	Neither	Disagree	Strongly disagree
32. I don't understand how some people can spend so much time working with computers and seem to enjoy them.	SA	A	N	D	SD
33. If given an opportunity, I would like to use and learn more about computers.	SA	A	N	D	SD
34. Computers make me feel impatient.	SA	A	N	D	SD
35. I get very frustrated when working with a computer.	SA	A	N	D	SD
36. I am not the type of person to do well with computers.	SA	A	N	D	SD
37. Learning about computers is a waste of time.	SA	A	N	D	SD
38. Computers are too complicated for the average person to use.	SA	A	N	D	SD
39. In today's world, everyone should know how to use computers in some way.	SA	A	N	D	SD
40. A computer is a tool, similar to a hammer or a calculator.	SA	A	N	D	SD

APPENDIX D. ENGINEERING DRAWING PRETEST

User name: ________________

Engineering Drawing Pretest



Directions

Before you begin, make sure that you have the following:

1. A copy of the test,
2. An answer sheet, and
3. Two sharpened #2 pencils.

Complete the student information portion of the answer sheet as shown in the example on the right.

You will have 50 minutes to take the test.

Do not turn this page until your instructor tells you to do so.

NAME :________________

This test is designed to determine how well you understand orthographic drawing. There are five parts to this test, with special directions for each parts.

Part A

Directions: In Part A, you are to choose the one best answer, (A), (B), (C), or (D), to each question. Then, on your answer sheet, find the number of the problem and mark the answer.

1. The top view of an object should be drawn
   (A). to the right of the front view
   (B). directly above the front view
   (C). anywhere on the same sheet
   (D). on a separate sheet of paper

2. Three dimensions are used in referring to an object drawn:
   (A). height, width, and length
   (B). height, width, and thickness
   (C). height, width, and depth
   (D). depth, thickness, and length

3. In multiview drawing, the width dimension is shown in both ________ and ________ views.
   (A). top and right side
   (B). front and right side
   (C). top and left side
   (D). top and front

4. Center lines should be used to indicate the center of hole
   (A). in the circular view only
   (B). in the hidden view only
   (C). only when the hole is in a cylinder
   (D). in both circular and hidden views

go on to the next page

5. Which of the following is a good rule to follow in deciding how many views to draw of an object?
   (A). Draw only the views that seem natural to you.
   (B). Draw only the front and top views of any object.
   (C). Draw only the front and right side views of any object.
   (D). Draw as many views as are needed to describe the object.

go on to the next page

Part B

<u>Directions</u>: Each problem in Part B is a pictorial drawing. You are to match a correct orthographic drawing given on the right side. Then, on your answer sheet, find the number of the problem and mark your answer.

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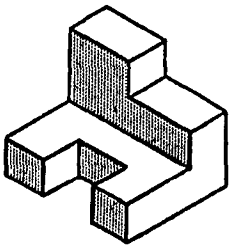

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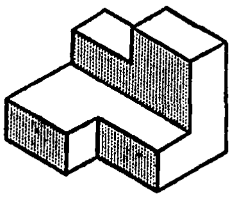

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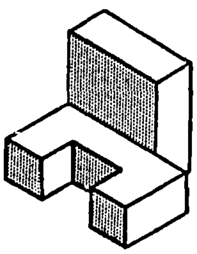

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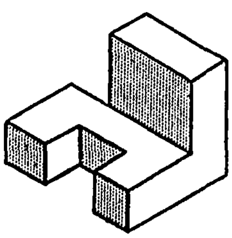

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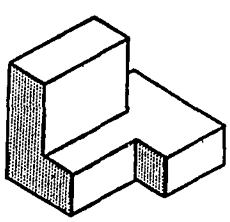

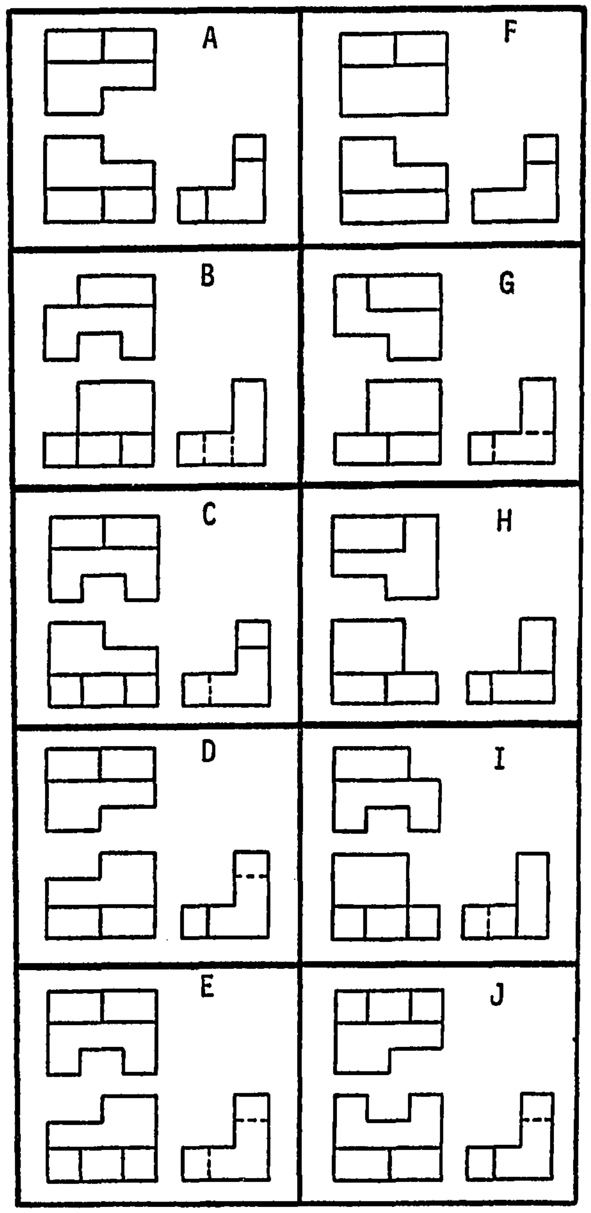

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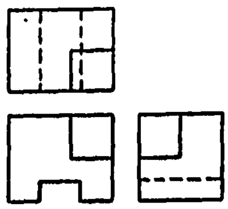
Part C

Directions: Each problem in Part C is a orthographic drawing. You are to identify a correct pictorial view given on right side. Then, on your answer sheet, find the number of the problem and mark your answer.

11



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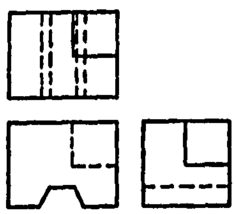

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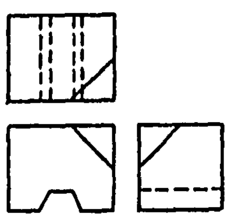

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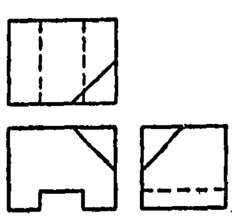

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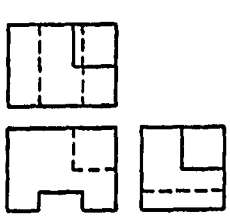

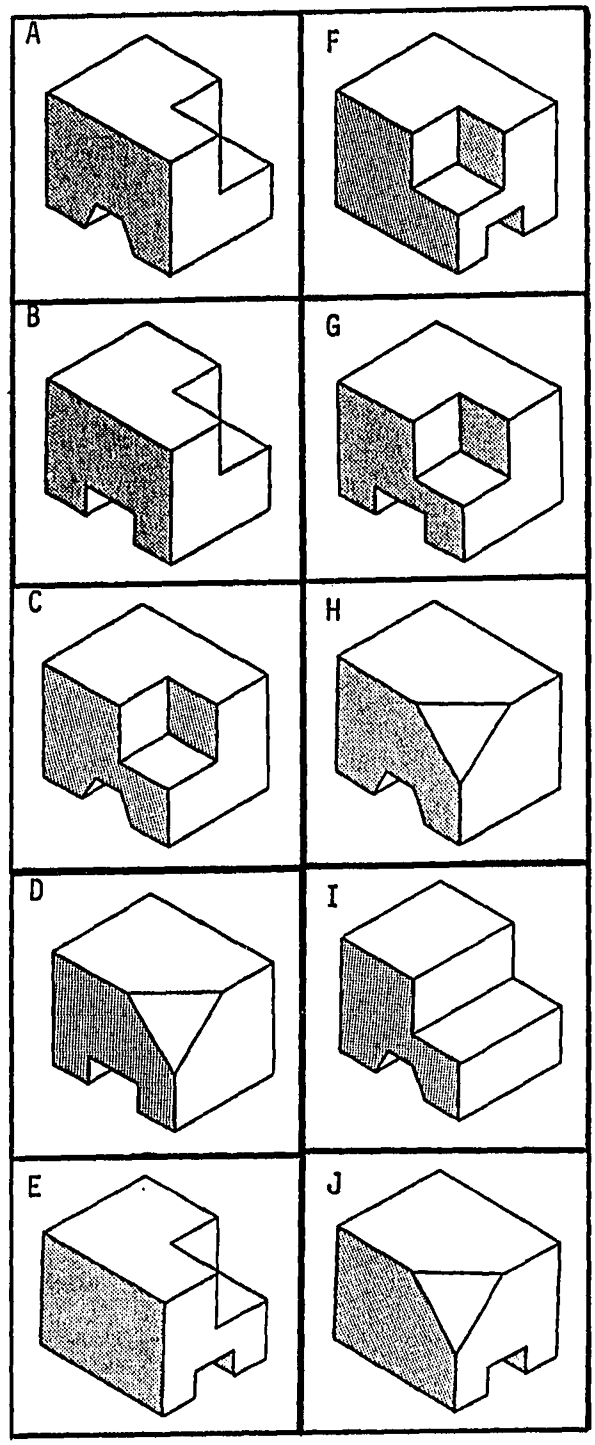

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Part D

Directions: In Part D, each problem consists of an incomplete orthographic drawing. You are to sketch a(some) missing line(s) at the right-side view.

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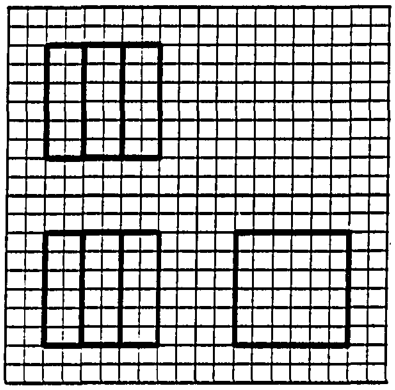

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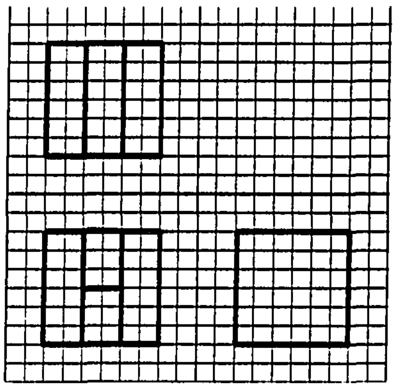

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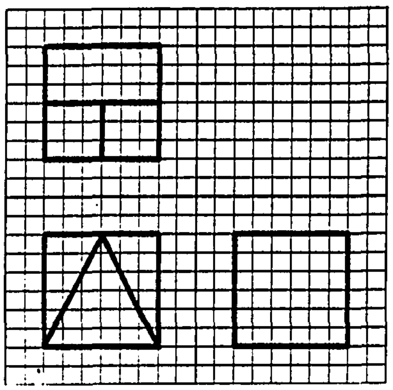

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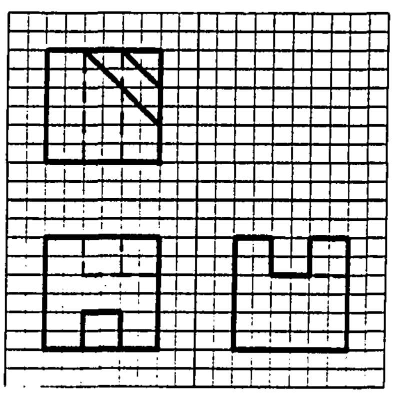

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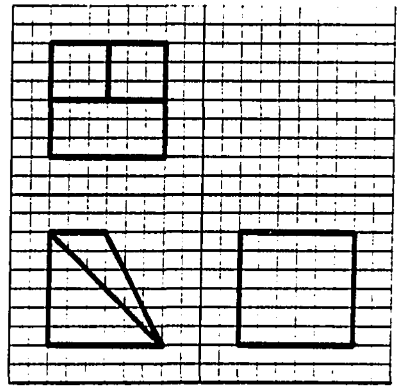

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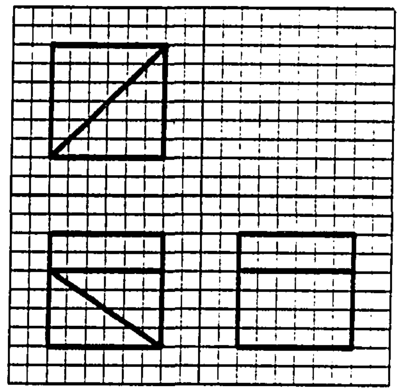

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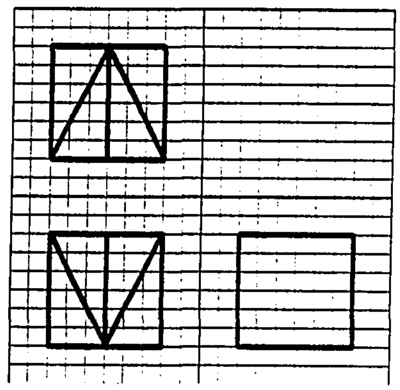

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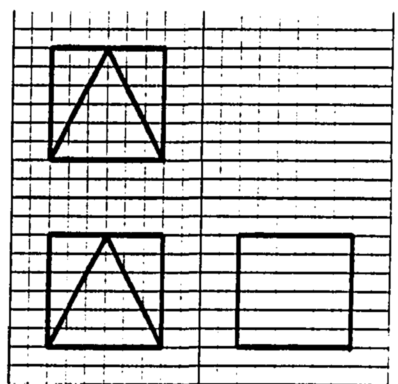

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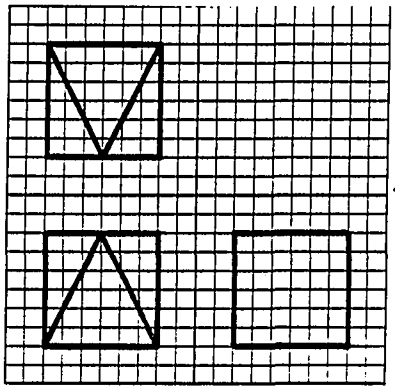

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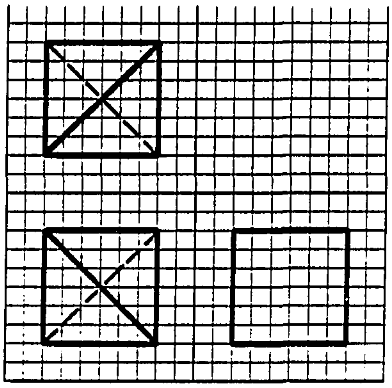

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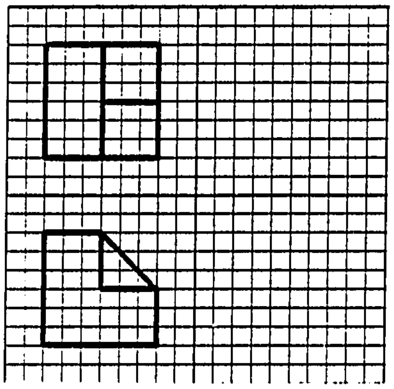
Part E

Directions: In Part E, each problem consists of a top and front views. You are to sketch a right-side view on a correct position.

26



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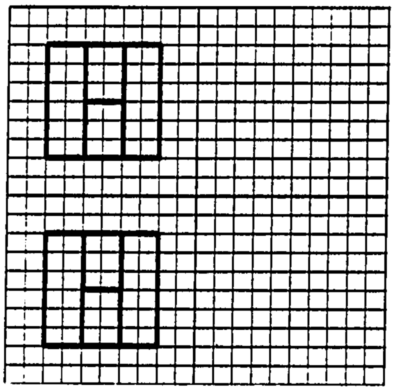

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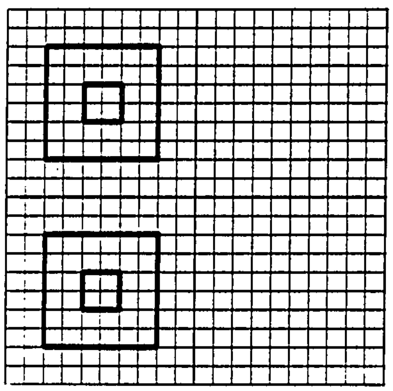

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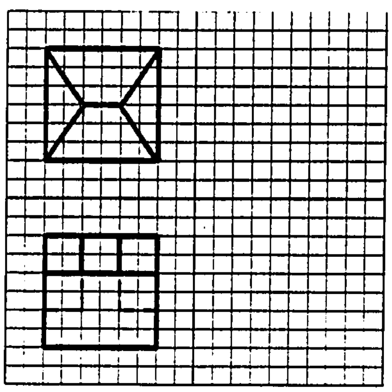

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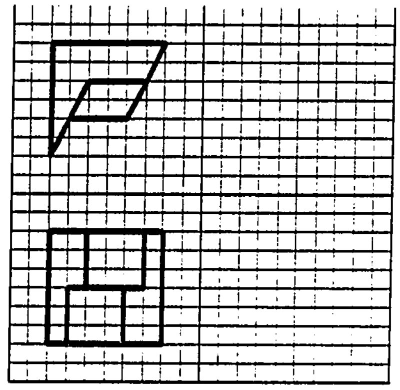


STOP

If you finish before time is called, check your work.

APPENDIX E. ENGINEERING DRAWING POSTTEST

User name: ________________

Engineering Drawing Posttest

Directions

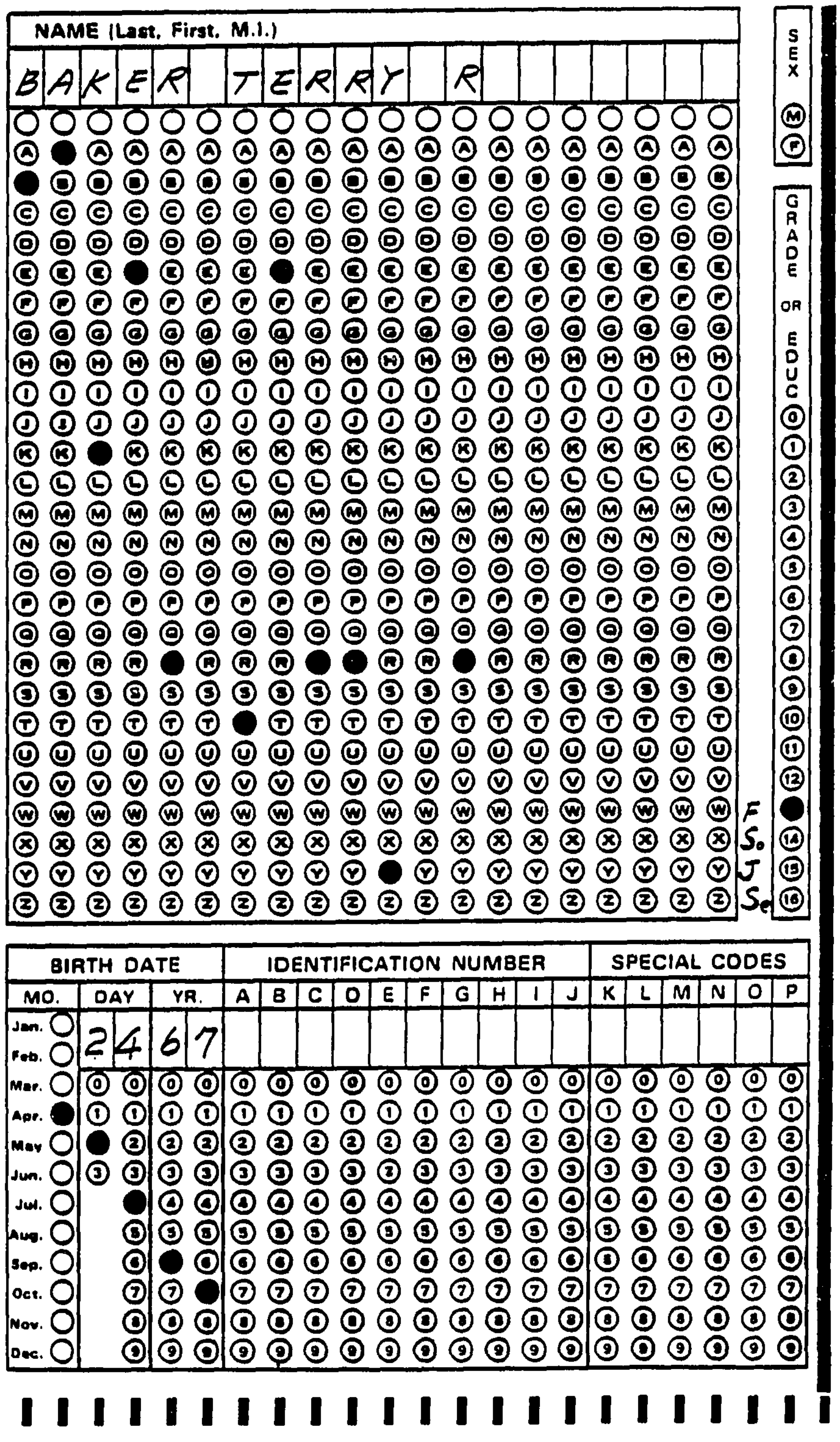
Before you begin, make sure that you have the following:

1. A copy of the test,
2. An answer sheet, and
3. Two sharpened #2 pencils.

Complete the student information portion of the answer sheet as shown in the example on the right.

You will have 50 minutes to take the test.

Do not turn this page until your instructor tells you to do so.



NAME :________________

This test is designed to determine how well you understand orthographic drawing. There are five parts to this test, with special directions for each part.

Part A

<u>Directions</u>: In Part A, you are to choose the <u>one</u> best answer, (A), (B), (C), or (D), to each question. Then, on your answer sheet, find the number of the problem and mark the answer.

1. Three dimensions are used in referring to an object drawn:
   (A). depth, thickness, and length
   (B). height, width, and depth
   (C). height, width, and thickness
   (D). height, width, and length

2. Which of the following is a good rule to follow in deciding how many views to draw of an object?
   (A). Draw as many views as are needed to describe the object.
   (B). Draw only the front and right-side views of any object.
   (C). Draw only the front and top views of any object.
   (D). Draw only the views that seem natural to you.

3. The top view of an object should be drawn
   (A). on a separate sheet of paper
   (B). anywhere on the same sheet
   (C). directly above the front view
   (D). to the right of the front view

4. In multiveiw drawing, the height dimension is shown in both __________ and ________ views.
   (A). top and front
   (B). top and right-side
   (C). front and right-side
   (D). top and left-side

go on to the next page

5. Center lines should be used to indicate the center of hole
   (A). in the hidden view only
   (B). in both circular and hidden views
   (C). in the circular view only
   (D). only when the hole is in a cylinder

go on to the next page

Part B

<u>Directions</u>: Each problem in Part B is a pictorial drawing. You are to match a correct orthographic drawing given on the right side. Then, on your answer sheet, find the number of the problem and mark your answer.

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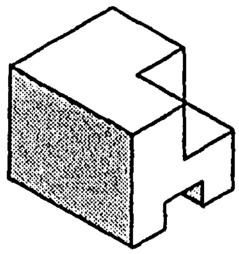

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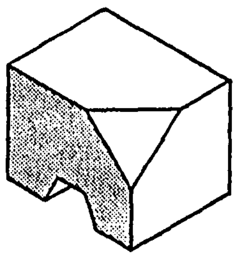

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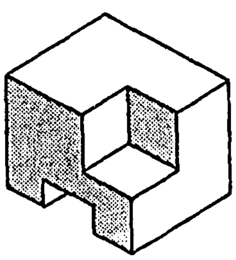

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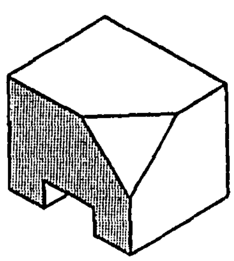

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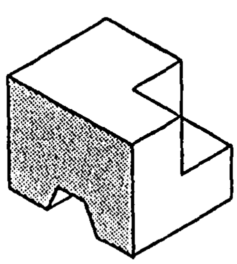

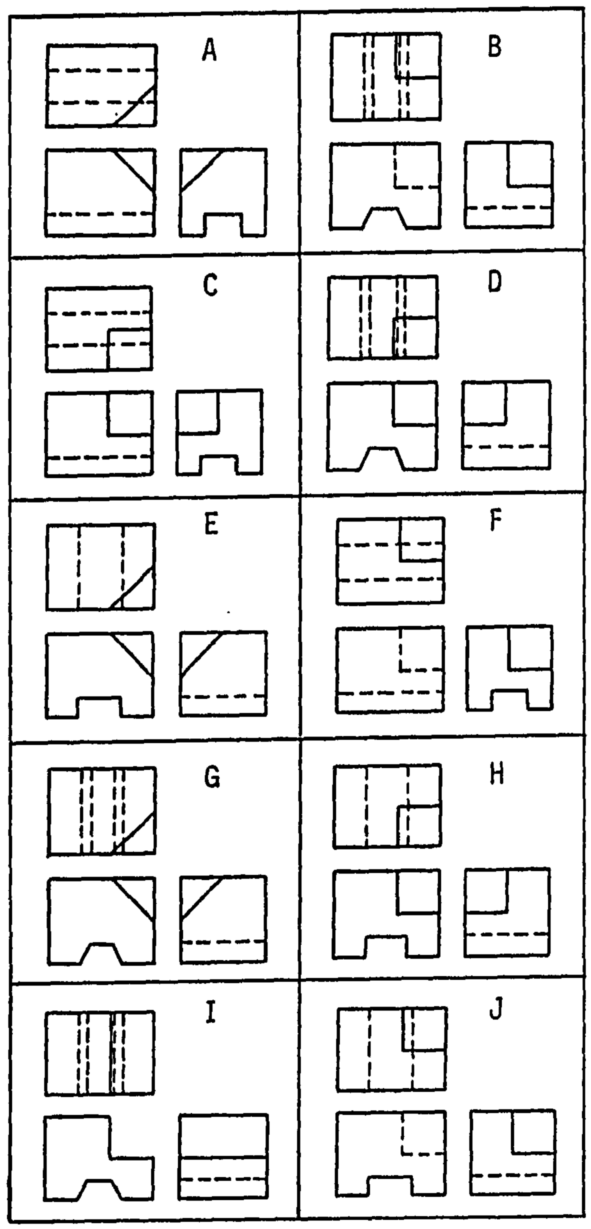

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Part C

Directions: Each problem in Part C is an orthographic drawing. You are to identify a correct pictorial view given on the right side. Then, on your answer sheet, find the number of the problem and mark your answer.

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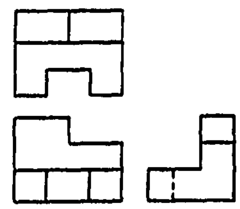

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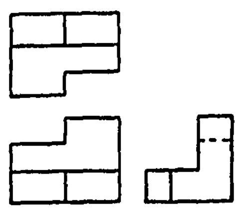

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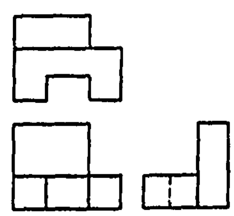

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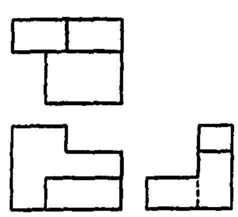

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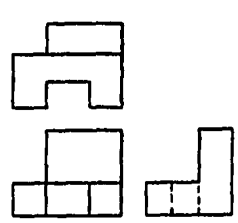

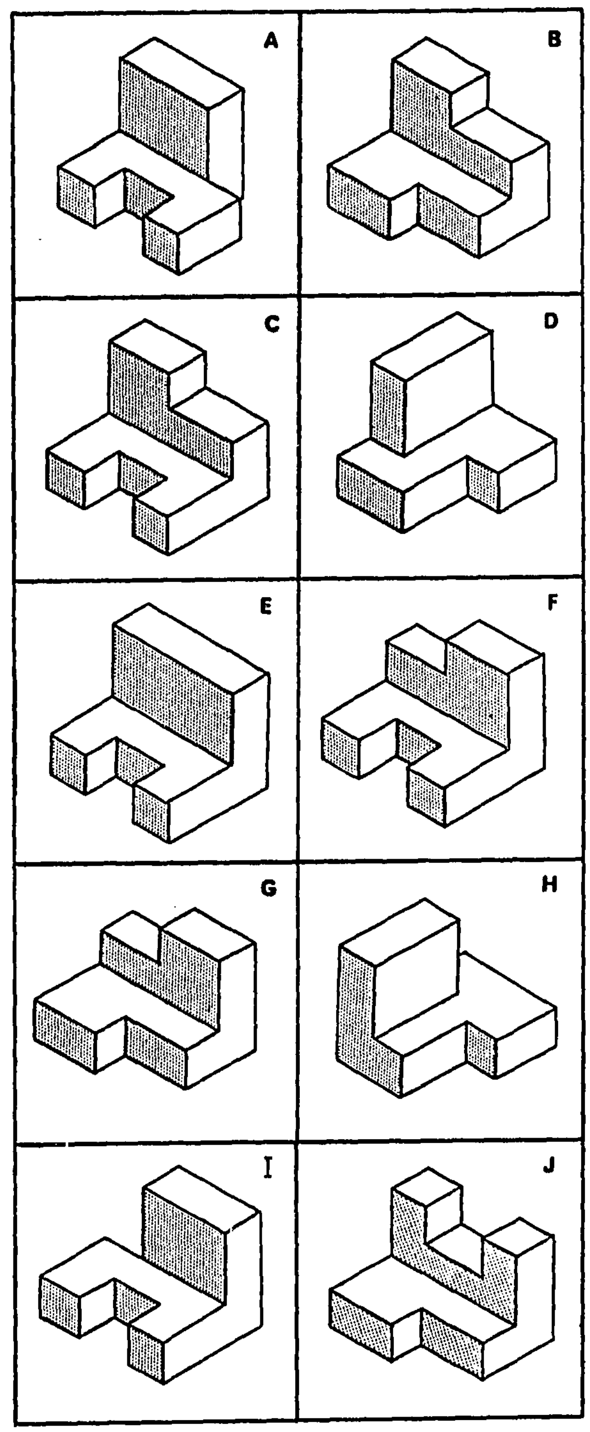

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Part D

Directions: In Part D, each problem consists of an incomplete orthographic drawing. You are to sketch a(some) missing line(s) at the top view only.

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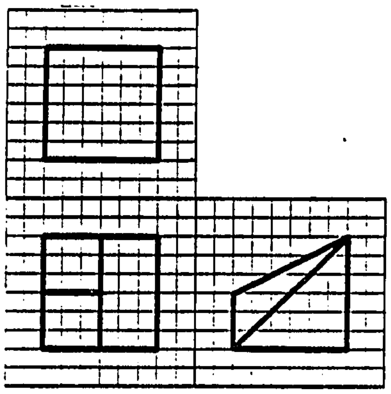

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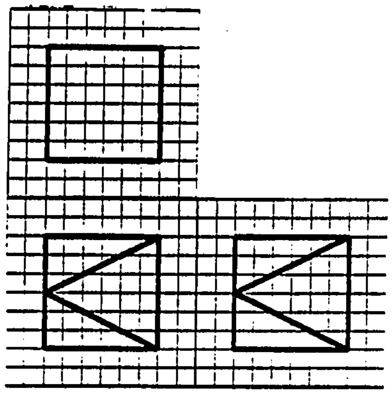

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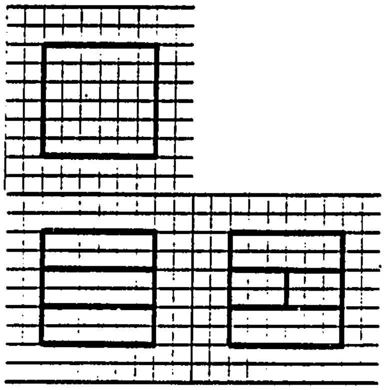

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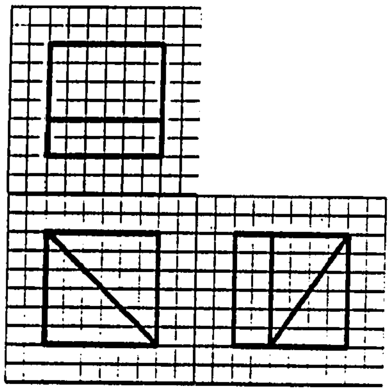

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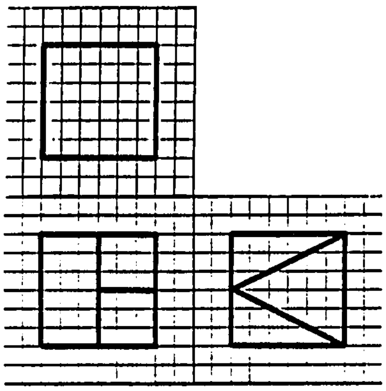
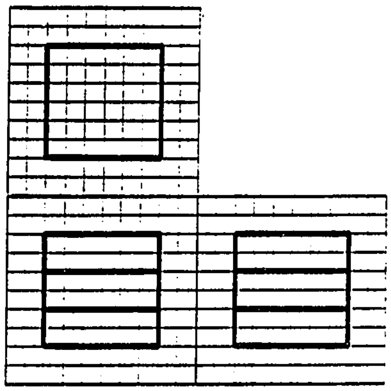


22



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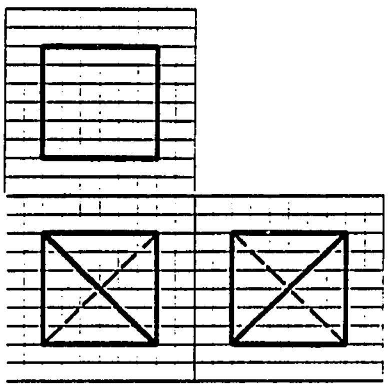
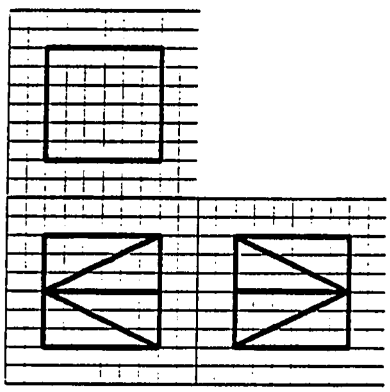


23



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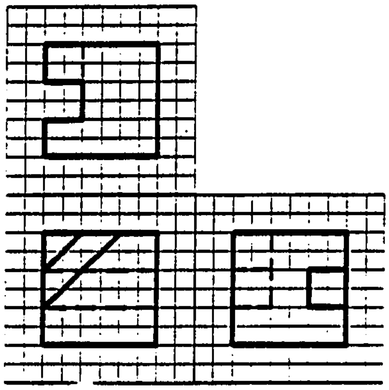
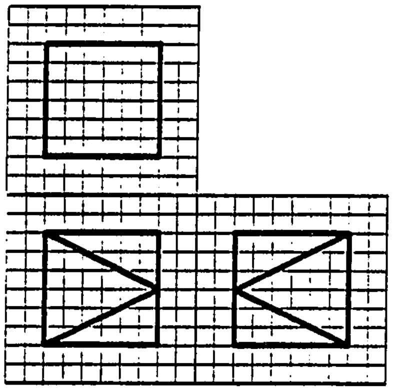
24 

25 

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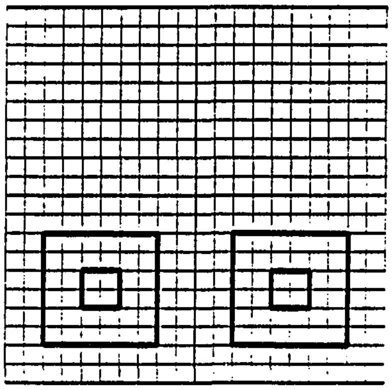
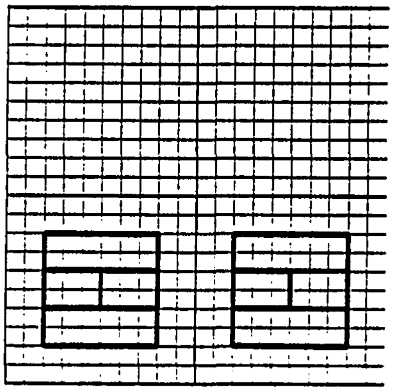
Part E

Directions: In Part E, each problem consists of a front and right-side view. You are to sketch a top view on a correct position.

26



27



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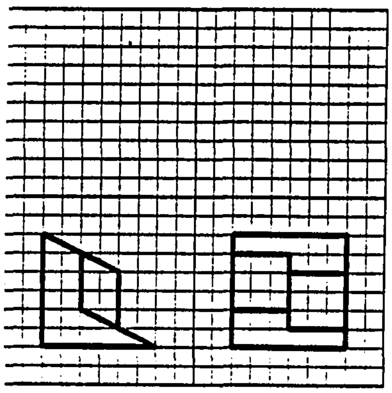

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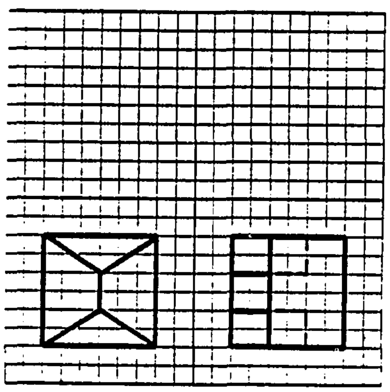

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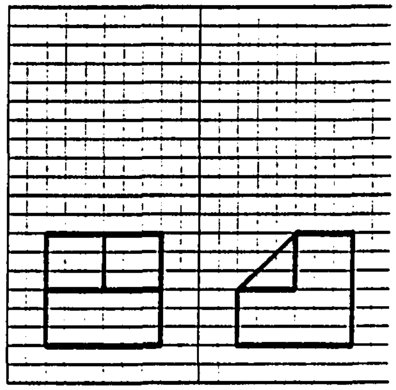
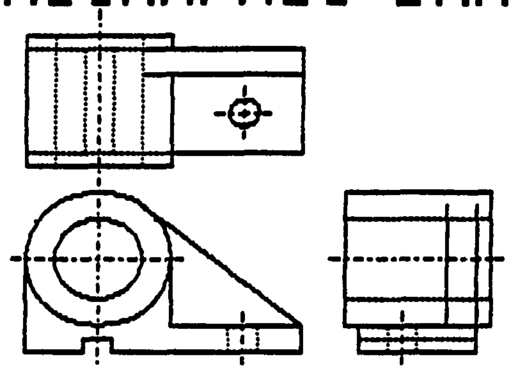


STOP

If you finish befor time is called, check your work.

APPENDIX F. SAMPLE RUN OF CAI PROGRAM

ORTHOGRAPHIC DRAWING



DESIGNED BY: WEN-SHUNG TAI

Please enter your name, social security number(last 6 digits) in one line, and press RETURN.

>

This lesson lets you review orthographic drawing and practice some problems.

Do you want to
(A). Practice
(B). Quit
(C). Review

Please type A, B, or C and press RETURN

>c

* Type ALL to review all information on orthographic drawing.
* Type a number(1-10) to review a specifc one.

N 1. objectives
N 2. introduction
N 3. definition of terms
N 4. pro and con
N 5. projection planes
N 6. orthographic views
N 7. selecting views
N 8. space dimensions
N 9. interpretation of orthographic views
N 10. classification of lines

NOTE: T indicates that you have practiced that section.
N indicates that you have NOT practiced that section.

>all

I. Objectives of this module:

1. To recognize the essential features of orthographic projection.

2. To understand the basic relationship of the principal projections(or views).

3. To be able to interpret pictorial images of objects or conceptual ideas and produce correct orthographic views of the objects or ideas.

4. To be able to delineate correct solutions to problems. This includes: proper convention, correct selection of necessary views, and maintaining correct projection.

Please press RETURN to continue

II. Introduction:

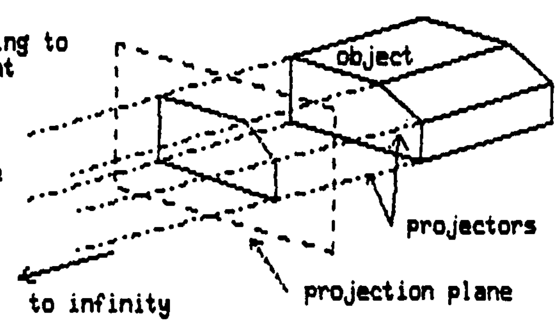
Typically, engineers design and develop machines and structures and direct their construction. Furthermore, in order to communicate every detail to manufacturing groups, descriptions must be prepared that show every aspect of the "shape" and "size" of each part and of the complete machine or structure.

Shape is described by projection, that is, by the process of causing an image to be formed by rays of sight taken in a particular direction from an object to a picture(projection) plane.

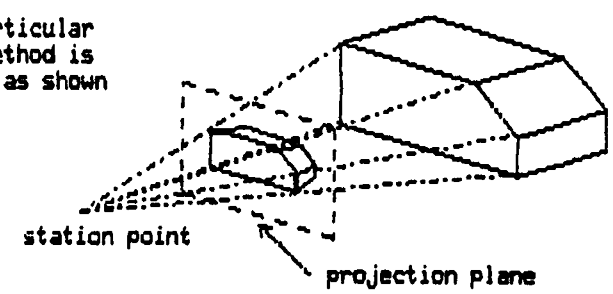
Please press RETURN to continue

The method of projection varies according to the direction in which the rays of sight are taken to the plane.

1. When the rays are perpendicular to the projection plane, the projective method is called "orthographic projection" as shown in the picture at the right.



2. When the rays are taken to a particular station point, the projective method is called "perspective projection" as shown in the picture at the right.



press RETURN to continue

3. When the rays are at an angle to the projection plane, the projective method is called "oblique projection."

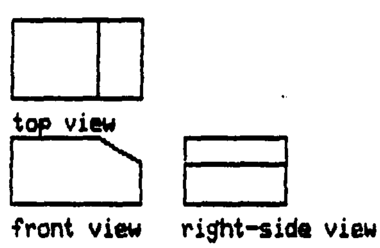
Please press RETURN to continue

III. Definitions:

Some new terms that will be used are defined as follows:

What is the multiview drawing?

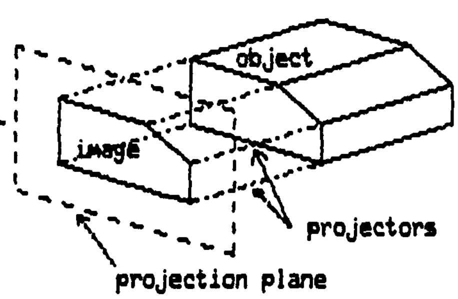
MULTIVIEW DRAWING is a projection drawing that incorporates several views of a part or assembly on one drawing.



Please press RETURN to continue

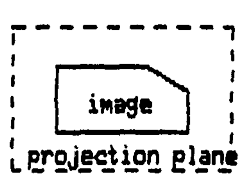
What is the projection?

PROJECTION is a system of representing an object by a line drawing (image) on a surface (plane) by using imaginary visual rays (projectors) emanating from various points on the object and extending toward the observor until they pierce a picture (or projection) plane.



What is orthographic projection?

ORTHOGRAPHIC PROJECTION is a system of drawing images of an object formed by projectors from the object perpendicular to one or more desired planes of projection.



Please press RETURN to continue

IV. The pro and con of multi-view drawings:

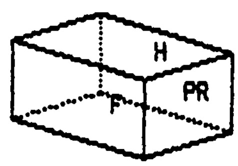
ADVANTAGE - The true shape of every surface(except oblique and incline surface) of object can be shown on a parallel plane of projection. Therefore, this type of drawing is best for providing precise information on the size and shape of an object.

DISADVANTAGE - It is difficult to visualize an image of the actual object from the different drawing(or view) of the faces, because each view provides only a 2-dimensional image.

Please press RETURN to continue

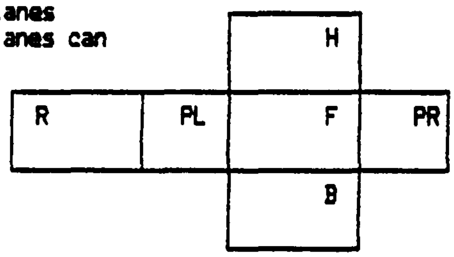
V. Planes of projection:

There are six principal planes of projection, coinciding with the six sides of a rectangular prism, or projection box as right above.



These six principal planes of projections are: horizontal plane(H), frontal plane(F), right profile plane(PR), left profile plane(PL), botton plane(B), and rear plane(R).

Once the images of all surfaces(planes) have been projected onto the images planes (projection planes), the image planes can be placed as right below.



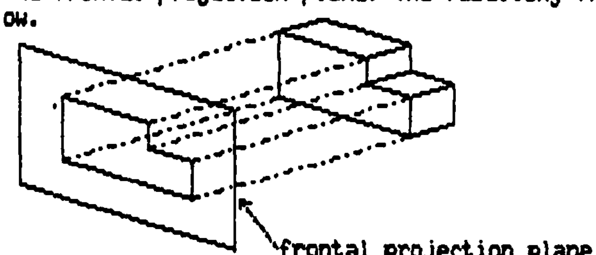
press RETURN to continue

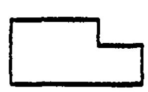
VI. Orthographic views of an object:

In an orthographic projection system, the views of an object are projected perpendicularly onto projection planes with parallel projectors.

For example, given a pictorial view(drawing) of an object at right,

to see the front view, the draftperson should imagine that he or she is in front of the object, so that the line of sight is perpendicular to the frontal projection plane. The resulting front view is shown at the right below.





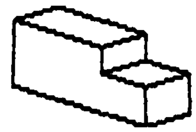
front view

press RETURN to continue

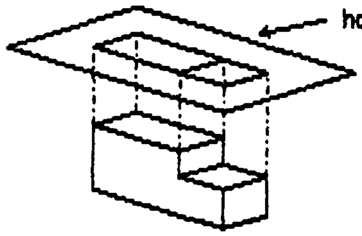
VI. Orthographic views of an object:

In an orthographic projection system, the views of an object are projected perpendicularly onto projection planes with parallel projectors.

For example, given a pictorial view(drawing) of an object at right,



to visualize the top view, the observation should be a birds-eye view perpendicular to the horizontal plane (that is perpendicular to the frontal projection planes). The resulting top view is shown at the right below.



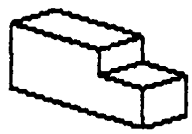
top view

press RETURN to continue

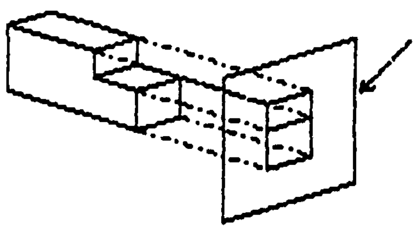
VI. Orthographic views of an object:

In an orthographic projection system, the views of an object are projected perpendicularly onto projection planes with parallel projectors.

For example, given a pictorial view(drawing) of an object at right,



to visualize the right-side view, the observation should be perpendicular to the right profile plane(that is perpendicular to both the frontal and horizontal plane). The resulting right-side view is shown at the right below.



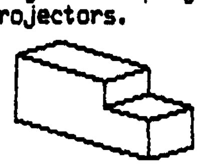
right-side view

press RETURN to continue

VI. Orthographic views of an object:

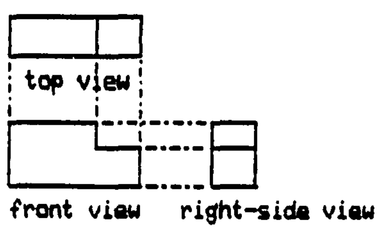
In an orthographic projection system, the views of an object are projected perpendicularly onto projection planes with parallel projectors.

For example, given a pictorial view(drawing) of an object at right,



all three views then should be positioned as follows:

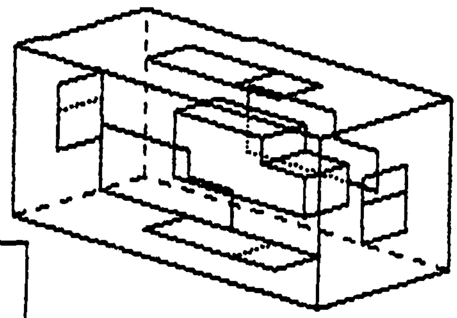
The top view is over the front view and the right-side view is to the right.



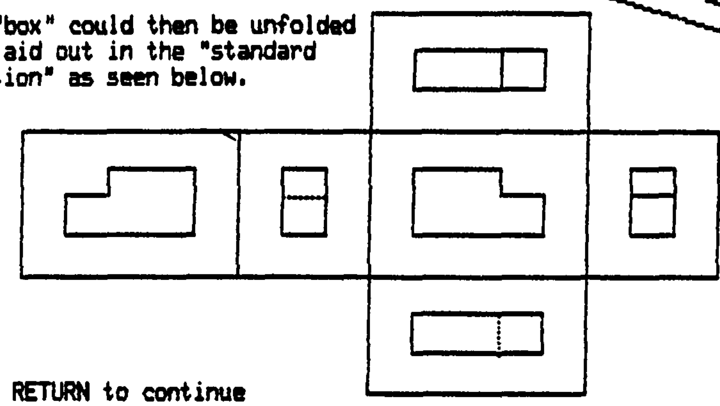
press RETURN to continue

VI. Orthographic views of an object:

We also can imagine that the object has been enclosed in a glass box composed of six principal projection planes on which the top, front, right-side, left-side, bottom, and rear views have been projected.



The "box" could then be unfolded and laid out in the "standard position" as seen below.

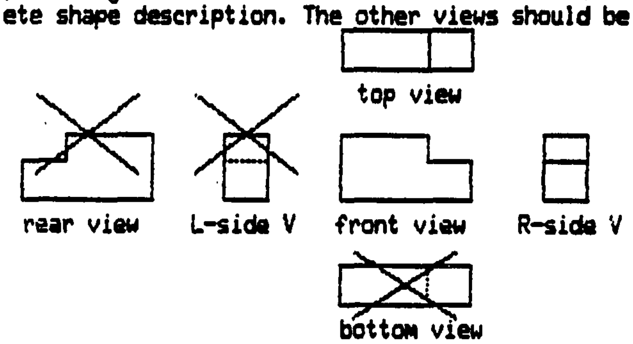


press RETURN to continue

VII. Selection of views:

As you know, we can draw at least six views of any object.
This does not mean that all of these views must be used, or are needed.

For example, in the following orthographic drawing, we only need the top, front, and right-side views because these three views already provide a complete shape description. The other views should be eliminated.

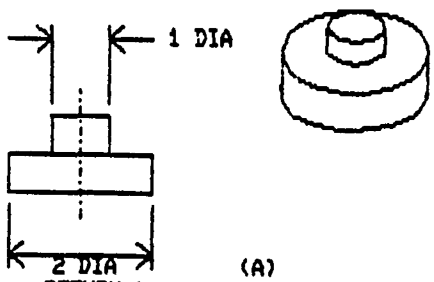


press RETURN to continue

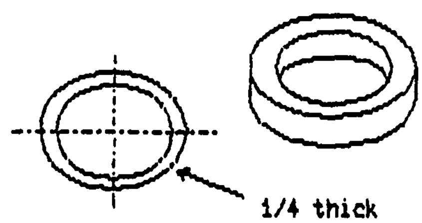
VII. Selection of views:

The various views of an object should be carefully selected to show every detail of size and shape, as well as the processes to be performed.
Usually, three views are drawn. However, drawing may vary from one or two views for a simple part to four or more views for a complicated part or assembly.

For example, cylinderical parts and those with a uniform thickness can be described in one view. In both cases, notes are used to explain the missing feature or dimension. A gasket is an example.



(A)

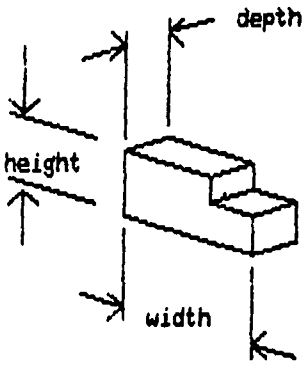


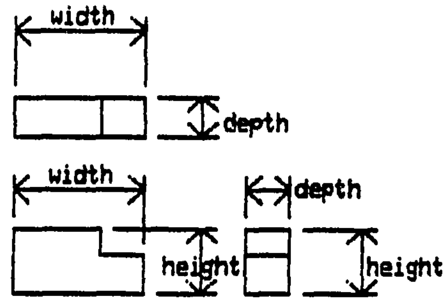
(B)

press RETURN to continue

VIII. Three space dimensions:

All objects, from single pieces to complicated structures, have distinct limits and are measurable by three space dimensions:height, width, and depth.





Press RETURN to continue

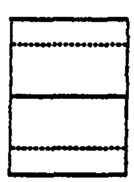
IX. Interpretation of orthographic projection:

Interpreting or reading an orthographic drawing is a matter of visualizing the object in the form of a 3-dimensional pictorial view.

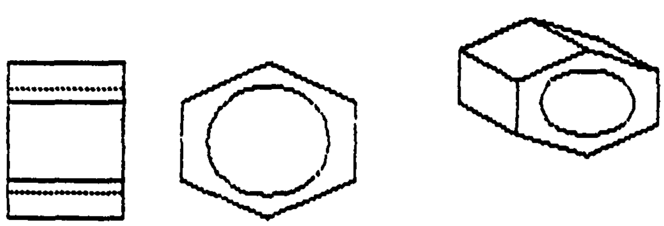
Although this is generally more difficult than constructing an orthographic drawing, visualization can be assisted greatly by preparation of a freehand pictorial sketch.

press RETURN to continue

Interpretation of the drawing will be easier if you remember that each line on the drawing represents:
- the edge of a surface
- an intersection of two surfaces
- the boundary or limit of a surface.



NOTE:
- green lines represent limit of surface
- yellow lines represent the intersection of two surfaces
- cyan lines represents the edge of a surface



press RETURN to continue

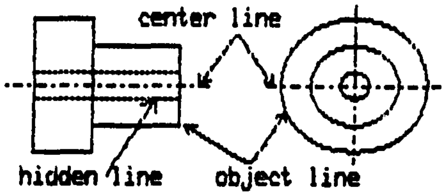
X. Classification of lines:

Three types of finished lines are used in the context of orthographic drawing are described as follows:

1. object lines: They sometimes are referred to as visible lines. they are shown on a drawing by dark, bold lines that represent the outline of the visible object.

2. hidden lines: They are used to show details that are behind some parts of the object. They are shown on a drawing by a line made of short dashes(or dots).

3. center lines: Center lines are used to locate the centers of a symmetrical object and path of motion.



press RETURN to continue

This lesson lets you review
orthographic drawing and
practice some problems.

Do you want to
(A). Practice
(B). Quit
(C). Review

Please type A, B, or C
and press RETURN

>a

This unit lets you practice
20 problems related to

N (A). Checking whether you actually understand
the basic concepts of orthographic drawing.(5 problems)

N (B). Identifing multiple views with the given
pictorial view and vice versa.(5 problems)

N (C). finding a correct or incorrect right side view
for the given top and front views.(10 problems)

You are encouraged to do A first, then B, then C.
Please type A, B, C, OR Q(to quit).

NOTE: T indicates that you have practiced that section.
N indicates that you have NOT practiced that section.

>

This unit lets you practice
20 problems related to

N (A). Checking whether you actually understand
the basic concepts of orthographic drawing.(5 problems)

N (B). Identifing multiple views with the given
pictorial view and vice versa.(5 problems)

N (C). finding a correct or incorrect right side view
for the given top and front views.(10 problems)

You are encouraged to do A first, then B, then C.
Please type A, B, C, OR Q(to quit).

NOTE: T indicates that you have practiced that section.
N indicates that you have NOT practiced that section.

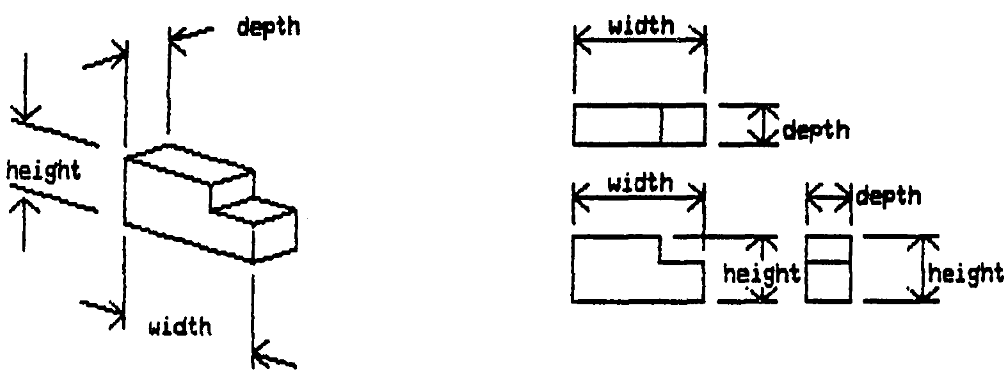
>a

How many overall dimensions are required on an orthographic drawing?
A. one
B. two
C. three
D. four

Enter your answer either A, B, C, or D
and press RETURN.
>a is not a correct answer.

you need review following unit.
press RETURN to begin review.

VIII. Three space dimensions:
All objects, from single pieces to complicated structures, have distinct limits and are measurable by three space dimensions:height, width, and depth.



Press RETURN to continue

How many overall dimensions are required on an orthographic drawing?
A. one
B. two
C. three
D. four

Enter your answer either A, B, C, or D
and press RETURN
>c
Congratulations!
Your answer is correct.
press RETURN to continue.

When the rays are perpendicular to the projection plane, the projection method is called

A. perspective projection
B. oblique projection
C. auxiliary projection
D. orthographic projection

Enter your answer either A, B, C, or D
and press RETURN.
>d

Congratulations!
Your answer is correct.
press RETURN to continue.

The line that is used to locate the centers of a symmetrical object and the path of motion is called

A. object line
B. extention line
C. motion line
D. center line

Enter your answer either A, B, C, or D
and press RETURN.
>d

Congratulations!
Your answer is correct.
press RETURN to continue.

How many views are usually needed(with notes) to completely describe an object having uniform thickness?

A. one
B. two
C. three
D. four

Enter your answer either A, B, C, or D
and press RETURN.
>a

Congratulations!
Your answer is correct.
press RETURN to continue.

Which type of drawing gives an accurate shape description and enables dimension & notes to be easily added?

A. pictorial drawing
B. multiview drawing
C. isometric drawing
D. perspective drawing

Enter your answer either A, B, C, or D
and press RETURN.
>b

Congratulations!
Your answer is correct.
press RETURN to continue.

This unit lets you practice
20 problems related to

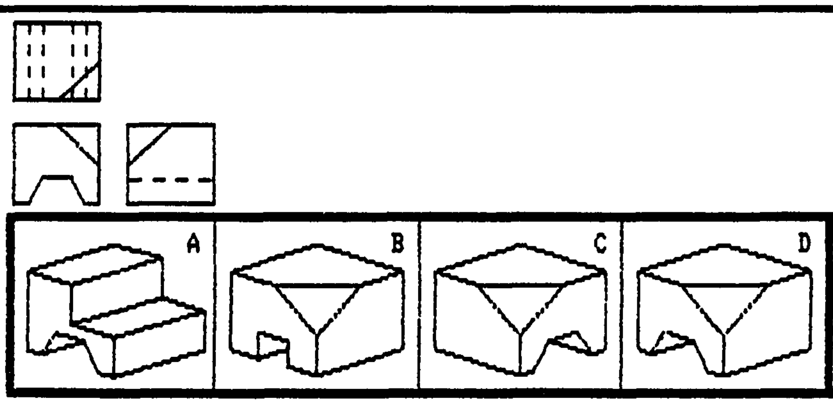
T (A). Checking whether you actually understand the basic concepts of orthographic drawing.(5 problems)

N (B). Identifing multiple views with the given pictorial view and vice versa.(5 problems)

N (C). finding a correct or incorrect right side view for the given top and front views.(10 problems)

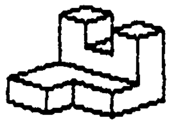
You are encouraged to do A first, then B, then C.
Please type A, B, C, OR Q(to quit).

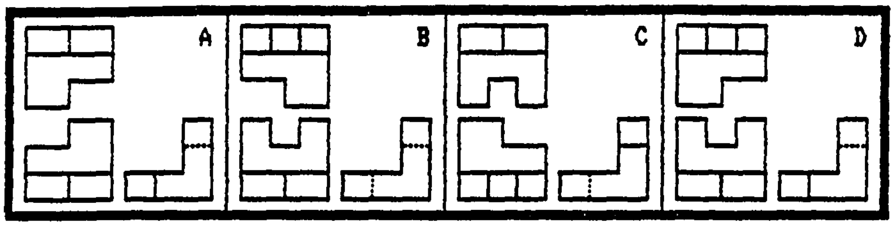
NOTE: T indicates that you have practiced that section.
N indicates that you have NOT practiced that section.
>b



Which one of the above is the correct pictorial drawing of the object whose multiple views are given?

Enter your answer either A, B, C, or D, and press RETURN.
>d
Congratulations!
Your answer is correct.
press RETURN to continue.



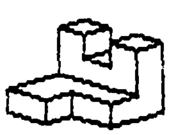


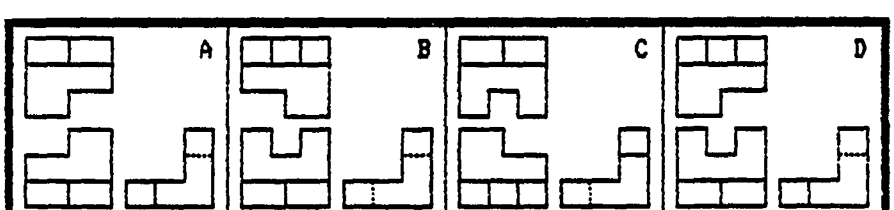
Which one of the above is the correct orthographic views
of the object whose pictorial drawing is given?

Enter your answer either A, B, C, or D, and press RETURN.
>b is not a correct answer.
You are recommended to read following message.
press RETURN to look it.

We recommend that you look at the pictorial view from different directions(top, front, and right side). Good luck!

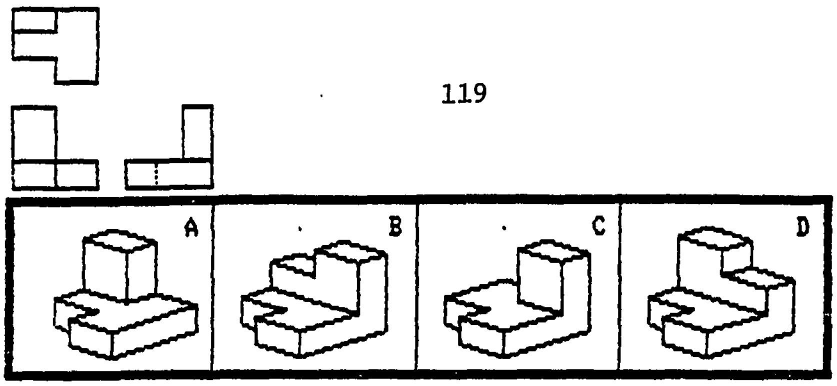
press RETURN to try again





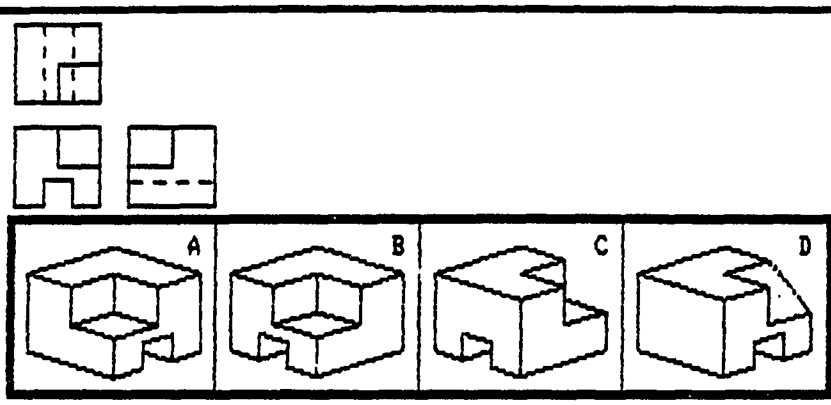
Which one of the above is the correct orthographic views
of the object whose pictorial drawing is given?

Enter your answer either A, B, C, or D, and press RETURN.
>d
Congratulations!
Your answer is correct.
press RETURN to continue.



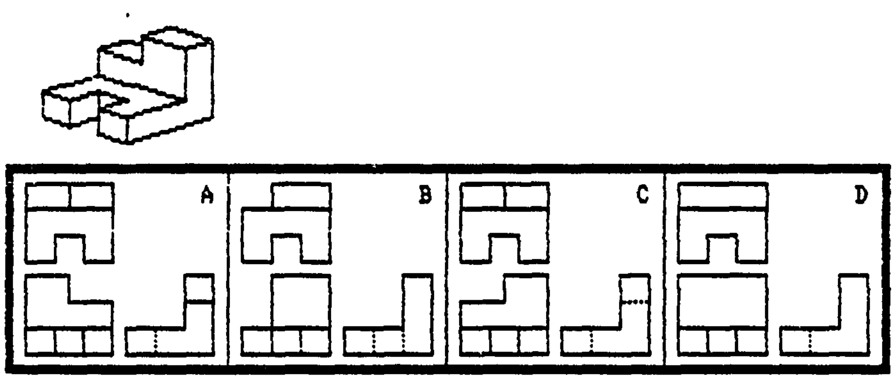
Which one of the above is correct pictorial drawing
of the object whose multiple views are given?

Enter your answer either A, B, C, or D, and press RETURN.
>



Which one of the above is the correct pictorial drawing
of the object whose multiple views are given?

Enter your answer either A, B, C, or D, and press RETURN.
>b



Which one of the above is the correct orthographic views
of the object whose pictorial view is given?

Enter your answer either A, B, C, or D, and press RETURN.
>

This unit lets you practice
20 problems related to

T (A). Checking whether you actually understand
the basic concepts of orthographic drawing.(5 problems)

T (B). Identifing multiple views with the given
pictorial view and vice versa.(5 problems)

N (C). finding a correct or incorrect right side view
for the given top and front views.(10 problems)

You are encouraged to do A first, then B, then C.
Please type A, B, C, OR Q(to quit).

NOTE: T indicates that you have practiced that section.
N indicates that you have NOT practiced that section.

>q

GOOD
Your score is 83 %

Please press RETURN to continue

This lesson lets you review
orthographic drawing and
practice some problems.

Do you want to
(A). Practice
(B). Quit
(C). Review

Please type A, B, or C
and press RETURN

>a

This unit lets you practice
20 problems related to

T (A). Checking whether you actually understand
the basic concepts of orthographic drawing. (5 problems)

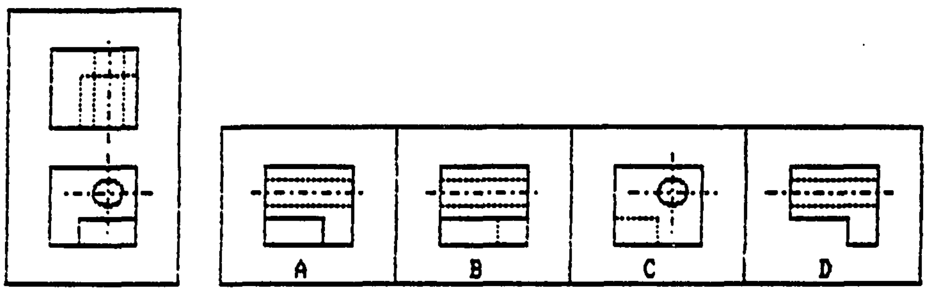
T (B). Identifing multiple views with the given
pictorial view and vice versa. (5 problems)

N (C). finding a correct or incorrect right side view
for the given top and front views. (10 problems)

You are encouraged to do A first, then B, then C.
Please type A, B, C, OR Q(to quit).

NOTE: T indicates that you have practiced that section.
N indicates that you have NOT practiced that section.

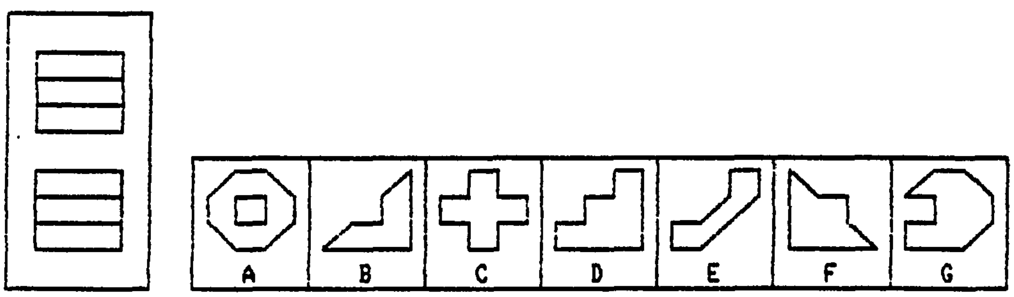
>c



Which right-side view is correct for the given top and front views?

Enter your answer either A, B, C, D, E, F, or G, and press RETURN.

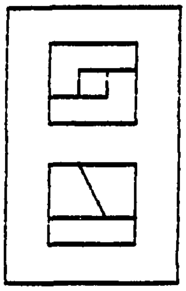
>a
congratulations!
Your answer is correct.
press RETURN to continue.

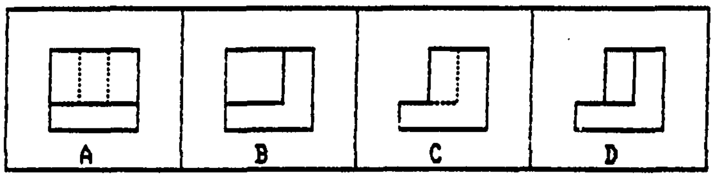


Which is NOT a correct right-side view of the given top and front views?

Enter your answer either A, B, C, D, E, F, or G, and press RETURN.

>f
congratulations!
Your answer is correct.
press RETURN to continue.

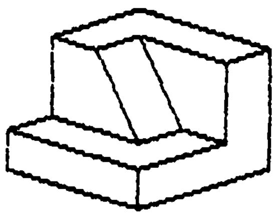




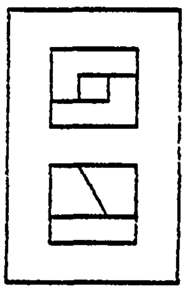
Which right-side view is correct for the given top and front views?

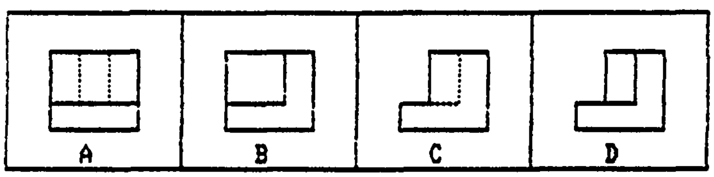
Enter your answer either A, B, C, D, E, F, or G, and press RETURN.

>c is not a correct answer.
press RETURN to look pictorial view.



The pictorial view is shown as above.
study it and press RETURN to try again.





Which right-side view is correct for the given top and front views?

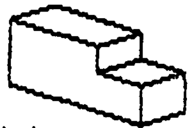
Enter your answer either A, B, C, or D
and press RETURN

>b is not a correct answer.
You should review following unit.
press RETURN to begin review.

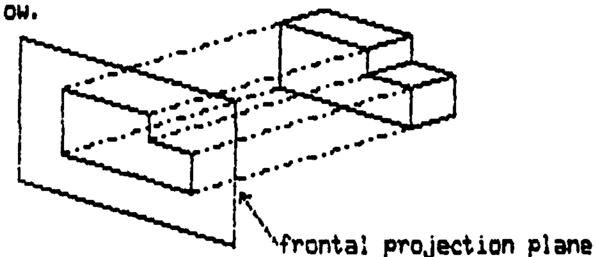
VI. Orthographic views of an object:

In an orthographic projection system, the views of an object are projected perpendicularly onto projection planes with parallel projectors.

For example, given a pictorial view(drawing) of an object at right,



to see the front view, the draftperson should imagine that he or she is in front of the object, so that the line of sight is perpendicular to the frontal projection plane. The resulting front view is shown at the right below.



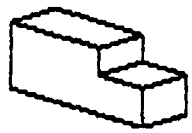
front view

press RETURN to continue

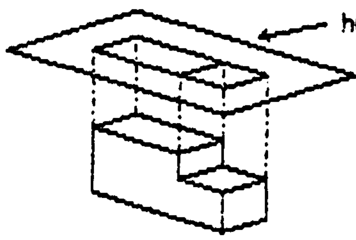
VI. Orthographic views of an object:

In an orthographic projection system, the views of an object are projected perpendicularly onto projection planes with parallel projectors.

For example, given a pictorial view(drawing) of an object at right,



to visualize the top view, the observation should be a birds-eye view perpendicular to the horizontal plane (that is perpendicular to the frontal projection planes). The resulting top view is shown at the right below.



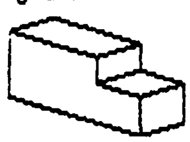
top view

press RETURN to continue

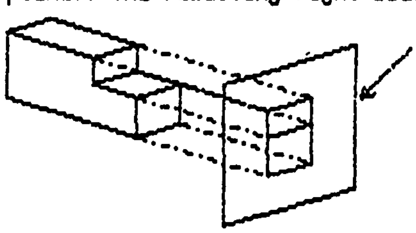
VI. Orthographic views of an object:

In an orthographic projection system, the views of an object are projected perpendicularly onto projection planes with parallel projectors.

For example, given a pictorial view(drawing) of an object at right,



to visualize the right-side view, the observation should be perpendicular to the right profile plane(that is perpendicular to both the frontal and horizontal plane). The resulting right-side view is shown at the right below.



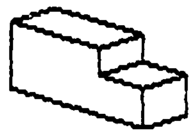
right-side view

press RETURN to continue

VI. Orthographic views of an object:

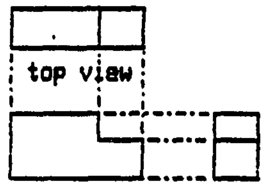
In an orthographic projection system, the views of an object are projected perpendicularly onto projection planes with parallel projectors.

For example, given a pictorial view(drawing) of an object at right,



all three views then should be positioned as follows:

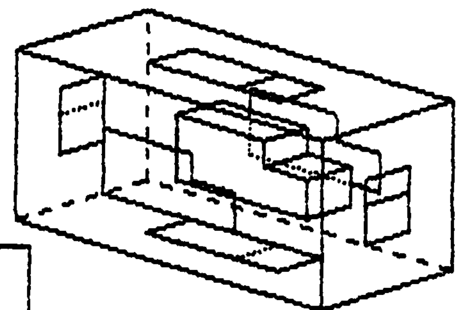
The top view is over the front view and the right-side view is to the right.



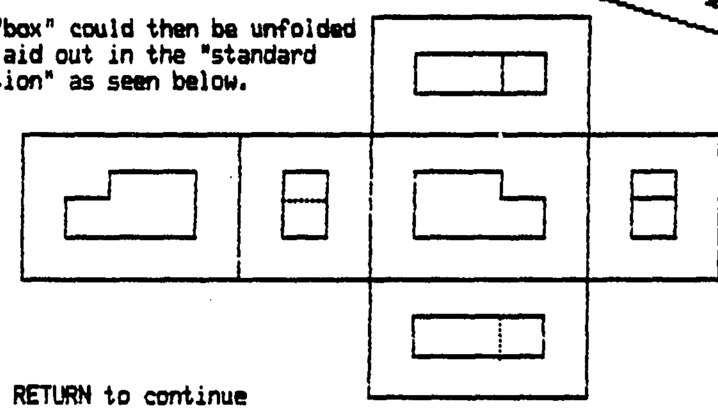
press RETURN to continue

VI. Orthographic views of an object:

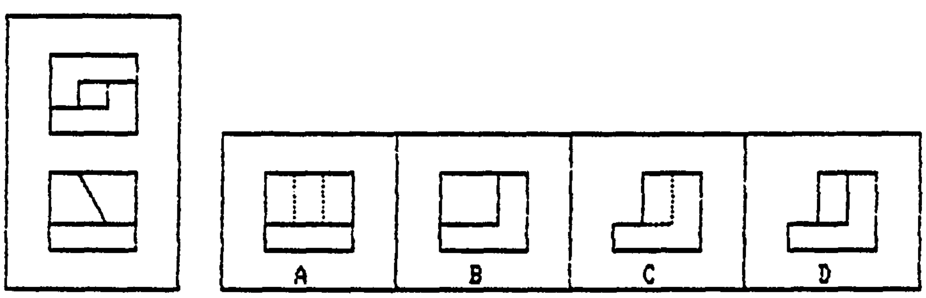
We also can imagine that the object has been enclosed in a glass box composed of six principal projection planes on which the top, front, right-side, left-side, bottom, and rear views have been projected.



The "box" could then be unfolded and laid out in the "standard position" as seen below.



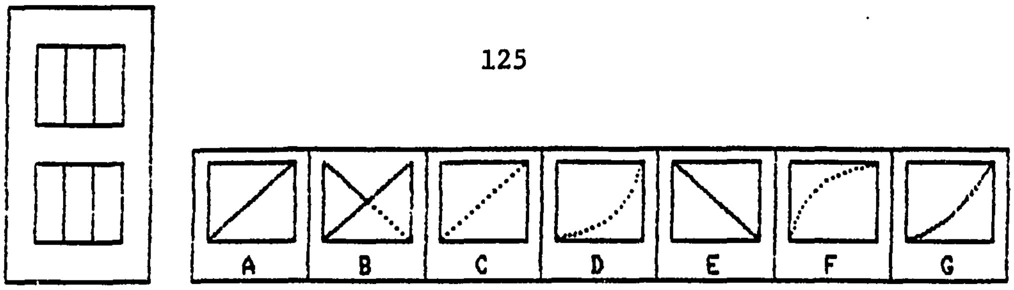
press RETURN to continue



Which right-side view is <u>correct</u> for the given top and front views?

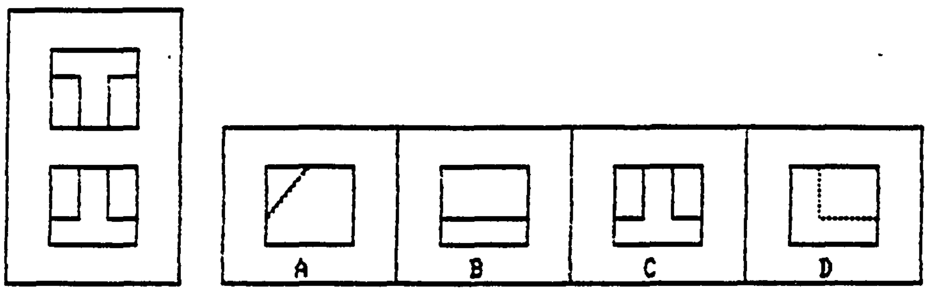
Enter your answer either A, B, C, D, E, F, or G
and press RETURN.

>a is not a correct answer.
The correct answer is D.
Study it and press RETURN to continue.



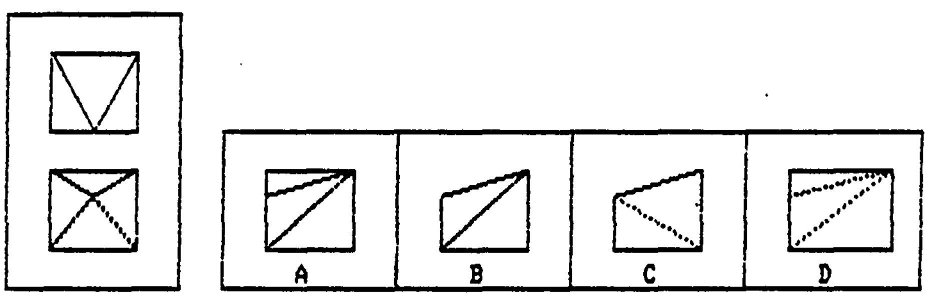
Which is NOT a correct right-side view of the given top and front views?

Enter your answer either A, B, C, D, E, F, or G, and press RETURN.
>



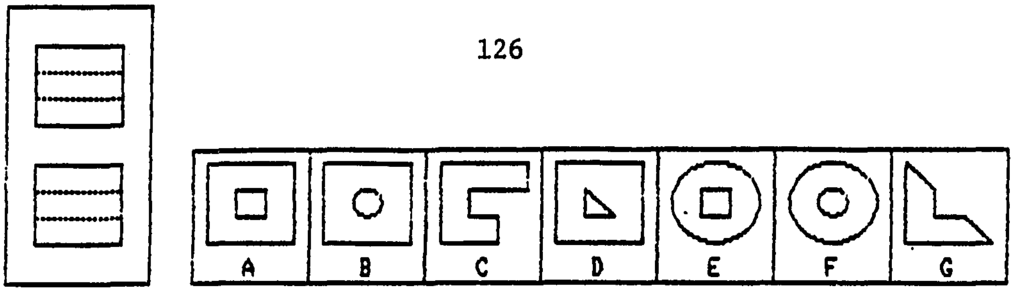
Which right-side view is correct for the given top and front views?

Enter your answer either A, B, C, D, E, F, or G, and press RETURN.
>



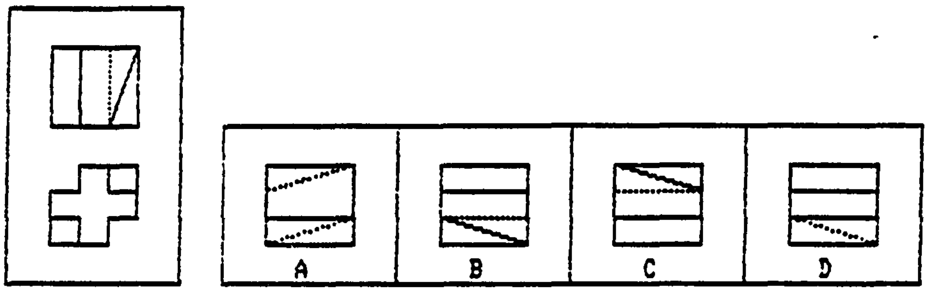
Which right-side view is <u>correct</u> for the given top and front views?

Enter your answer either A, B, C, D, E, F, or G, and press RETURN.
>



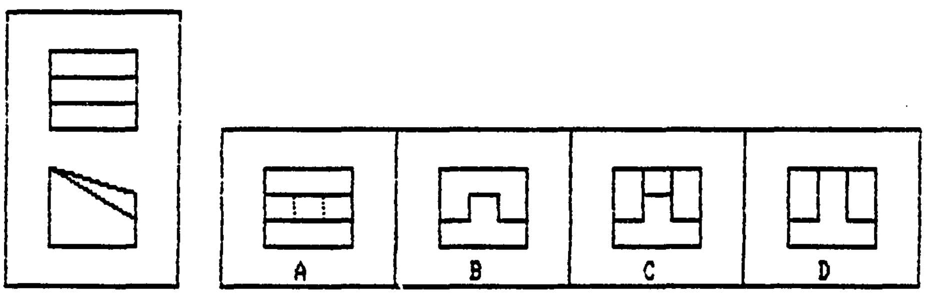
Which is NOT a correct right-side view of the given top and front views?

Enter your answer either A, B, C, D, E, F, or G, and press RETURN.
>



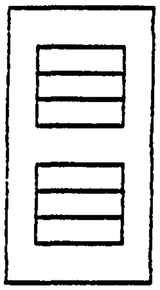
Which right-side view is <u>correct</u> for the given top and front views?

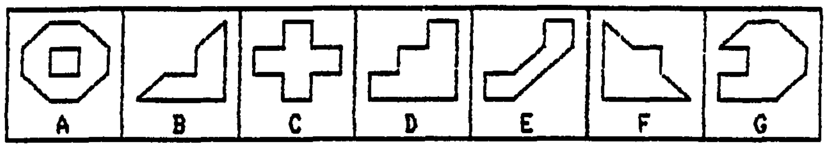
Enter your answer either A, B, C, D, E, F, or G, and press RETURN.
>



Which right-side view is <u>correct</u> for the given top and front views?

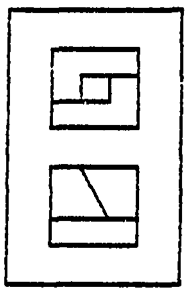
Enter your answer either A, B, C, D, E, F, or G, and press RETURN.
>

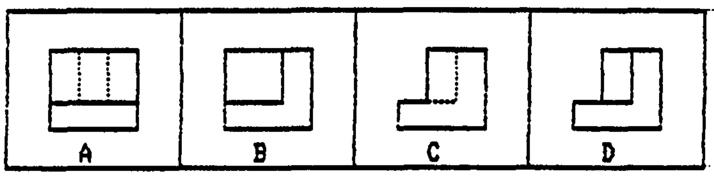




Which is NOT a correct right-side view of the given top and front views?

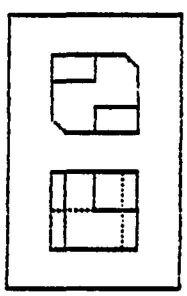
Enter your answer either A, B, C, D, E, F, or G, and press RETURN.
>

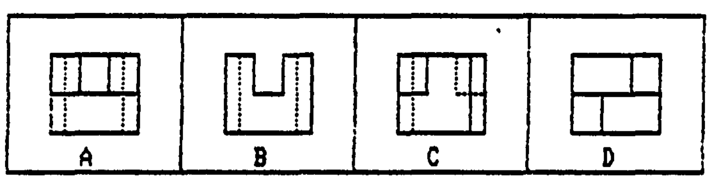




Which right-side view is <u>correct</u> for the given top and front views?

Enter your answer either A, B, C, D, E, F, or G, and press RETURN.
>





Which right-side view is <u>correct</u> for the given top and front views?

Enter your answer either A, B, C, D, E, F, or G, and press RETURN.
>

```
This lesson lets you review
orthographic drawing and
practice some problems.

     Do you want to
     (A). Practice
     (B). Quit
     (C). Review

     Please type A, B, or C
     and press RETURN
     >b
```

```
GOOD-BYE
```

APPENDIX G.

CHARACTERISTICS OF SUBJECTS

Characteristics	N	Percentage
Treatment		
Control	45	50.6
Experimental	44	49.4
Total	89	100.0
Sex		
Male	84	94.4
Female	5	5.6
Total	89	100.0
Grade		
Freshman	46	51.7
Sophomore	37	41.6
Junior	5	5.6
Unknown	1	1.1
Total	89	100.0
Major		
Aerospace Eng.	10	11.2
Agricultural Eng.	4	4.5
Chemical Eng.	7	7.9
Civil Eng.	7	7.9
Electrical Eng.	20	22.5
Industrial Eng.	4	4.5
Mechanical Eng.	23	25.8
Nuclear Eng.	2	2.2
Undeclared	2	2.2
Total	89	100.0

APPENDIX H. MEANS, STANDARD DEVIATIONS, AND FREQUENCIES OF ATTITUDE TOWARD ENGINEERING DRAWING ITEMS

Attitude Toward Engineering Graphics

Item

Item	N	Mean	S.D.	A	B	C	D	E
				Frequency				
1. When an engineering graphics problem arises that I can't immediately solve, I stick with it until I have the solution.	89	4.080	.572	0	3	2	68	15
2. I don't understand how some people can spend so much time on engineering graphics and seem to enjoy it.	89	3.753	.908	1	9	17	46	16
3. It would not bother me at all to take more engineering graphics courses.	89	3.584	.951	1	14	18	44	12
4. Engineering graphics is a worthwhile and necessary subject.	89	4.236	.565	0	1	3	59	26
5. Taking engineering graphics is a waste of time.	89	4.449	.564	0	0	3	43	43
6. Engineering graphics usually make me feel uncomfortable and nervous.	89	3.562	.965	3	10	21	44	11
7. I feel confident about my ability to deal with engineering graphics.	89	3.719	.917	3	5	20	47	14
8. For some reason even though I study, engineering graphics seems unusually hard for me.	89	3.528	.906	3	10	19	51	14
9. I think I could handle more difficult engineering graphics.	89	3.427	.824	2	10	28	46	3
10. I am not the type of person to do well in the engineering graphics.	89	3.663	.778	0	9	17	58	5
11. I am sure I can learn engineering graphics.	89	4.438	.521	0	0	1	48	40
12. I don't think I could do advanced engineering graphics.	89	3.719	.707	0	5	23	53	8
13. Engineering graphics doesn't scare me at all.	89	3.348	.893	1	16	29	37	6
14. Engineering graphics makes me feel uneasy and confused.	89	3.663	.825	26	6	20	53	8
15. I haven't usually worried about being able to solve engineering graphics problems.	88	3.409	.910	1	18	18	46	5

Item		Mean	S.D.	Frequency A	B	C	D	E
16.	I get a sinking feeling when I think of trying hard engineering graphics problems.							
	89	3.337	.916	2	17	23	43	4
17.	Engineering graphics is enjoyable and stimulating to me.							
	89	3.517	.693	0	6	35	44	4
18.	The challenge of engineering graphics problems does not appeal to me.							
	89	3.708	.694	0	7	17	60	5
19.	When a question is left unanswered in engineering graphics class, I continue to think about it afterward.							
	89	3.652	.740	0	9	18	57	5
20.	I do as little work in engineering graphics as possible.							
	89	3.764	.640	0	6	13	66	4

APPENDIX I. MEANS, STANDARD DEVIATIONS, AND FREQUENCIES OF ATTITUDE TOWARD COMPUTER ITEMS

Attitude Toward Computers

Item

	N	Mean	S.D.	Frequency A	B	C	D	E
21. Computers do not scare me at all.	89	3.562	1.167	1	22	16	26	24
22. I prefer to stay away from computers.	89	3.685	1.072	3	12	15	39	20
23. I think working with computers would be enjoyable and stimulating.	89	3.730	.863	1	7	21	46	14
24. Figuring out computer problems does not appeal to me.	89	3.539	.978	0	16	24	34	15
25. Computers are fascinating and fun.	89	3.809	.838	0	8	17	48	16
26. Working with a computer would make me very nervous.	89	3.831	.815	0	8	14	52	15
27. I do enjoy talking with others about computers.	89	3.022	.953	3	26	30	26	4
28. I will do as little work with computers as possible.	89	3.818	.836	0	8	16	48	16
29. I feel confident about my ability to deal with computers.	89	3.652	1.035	3	10	20	38	18
30. I get a sinking feeling when I think of trying to use a computer.	89	3.742	.924	1	9	19	43	17
31. I would like working with computers.	89	3.865	.855	1	5	18	46	19
32. I don't understand how some people can spend so much time working with computers and seem to enjoy them.	89	3.618	1.028	3	10	22	37	17
33. If given an opportunity, I would like to use and learn more about computers.	89	4.225	.719	0	2	9	45	33
34. Computers make me feel impatient.	89	2.843	.952	4	35	22	27	1
35. I get very frustrated when working with a computer.	89	2.775	.938	6	31	31	19	2
36. I am not the type of person to do well with computers.	89	3.775	.794	1	6	16	55	11

Item	N	Mean	S.D.	Frequency A	B	C	D	E
37. Learning about computers is a waste of time.	89	4.506	.525	0	0	1	42	46
38. Computers are too complicated for the average person to use.	89	4.124	.915	2	5	5	45	32
39. In today's world, everyone should know how to use computers in some way.	89	4.213	.776	1	3	4	49	32
40. A computer is a tool, similar to a hammer or a calculator.	89	4.180	.912	1	7	3	42	36

APPENDIX J. HUMAN SUBJECTS FORM

INFORMATION ON THE USE OF HUMAN SUBJECTS IN RESEARCH
IOWA STATE UNIVERSITY
(Please follow the accompanying instructions for completing this form.)

1. Title of project (please type): The study of the interaction between student characteristics and teaching method of ~~achievement of selected drafting~~ concepts.

2. I agree to provide the proper surveillance of this project to insure that the rights and welfare of the human subjects are properly protected. Additions to or changes in procedures affecting the subjects after the project has been approved will be submitted to the committee for review.

Wen-Shung Tai	Aug 12 '86	Wen-Shung Tai
Typed Named of Principal Investigator	Date	Signature of Principal Investigator

B7 A I.Ed II	296-8529
Campus Address	Campus Telephone

RECEIVED AUG 20 '86 GRADUATE COLLEGE

3. Signatures of others (if any) | Date | Relationship to Principal Investigator

Signatures of others (if any)	Date	Relationship to Principal Investigator
William G. Miller	8/18/86	Committee Chair

4. ATTACH an additional page(s) (A) describing your proposed research and (B) the subjects to be used, (C) indicating any risks or discomforts to the subjects, and (D) covering any topics checked below. CHECK all boxes applicable.

- ☐ Medical clearance necessary before subjects can participate
- ☐ Samples (blood, tissue, etc.) from subjects
- ☐ Administration of substances (foods, drugs, etc.) to subjects
- ☐ Physical exercise or conditioning for subjects
- ☐ Deception of subjects
- ☐ Subjects under 14 years of age and(or) ☐ Subjects 14-17 years of age
- ☐ Subjects in institutions
- ☐ Research must be approved by another institution or agency

5. ATTACH an example of the material to be used to obtain informed consent and CHECK which type will be used.

- ☐ Signed informed consent will be obtained.
- ☒ Modified informed consent will be obtained.

6.

	Month	Day	Year
Anticipated date on which subjects will be first contacted:	Sept.	1	1986
Anticipated date for last contact with subjects:	Oct.	31	1986

7. If Applicable: Anticipated date on which audio or visual tapes will be erased and(or) identifiers will be removed from completed survey instruments: Nov. 31 1986 (Month Day Year)

8.

Signature of Head or Chairperson	Date	Department or Administrative Unit
Trevor G. Howe	8/18/86	Ind. Ed. & Tech.

9. Decision of the University Committee on the Use of Human Subjects in Research:

☐ Project Approved ☐ Project not approved ☐ No action required

George G. Karas		
Name of Committee Chairperson	Date	Signature of Committee Chairperson

APPENDIX K. CAI LESSON SOURCE CODE

```
$$**********************************************************************
$$ .                                                                  **
$$                      ORTHOGRAPHIC DRAWING                          **
$$                                                                    **
$$**********************************************************************

$$**********************************************************************
$$                                                                    **
$$    ADVISOR     : Dr. Miller                                        **
$$    WRITTEN BY  : WEN-SHUNG TAI                                     **
$$    DATE        : JAN 8,1986                                        **
$$                                                                    **
$$**********************************************************************

$$**********************************************************************
$$                                                                    **
$$  This lesson lets student learn some basic ideas of ortho-         **
$$  graphic drawing and practice identification of the three          **
$$  veiws of orthographic projection given pictorial view and         **
$$  vise-versa.                                                       **
$$                                                                    **
$$**********************************************************************
LESSON  ortho
erase
define  go_on, go_onl : boolean
assign  go_on := true
assign  go_onl := true
define  done_once, checkP[3], checkR[10], checkPP[3]  : boolean
define  y,z, count, percent: integer
define  x = 10
define  p = 5
define  arrayl[p,4], array2[p,4], array3[x,4], ssno : string
do      checkprac
do      initial1
do      initial2
do      initial3
do      cover
score   false
do      setid

loop    go_on
. assign        count := 0
. do    menu
. query 2220
. right a|practice|A
. . do  practice
. right b|quit|B
. . assign      go_on := false
. right c|review|C
. . do  review
. wrong
. . fcolor      red
. . size        1,2
. . at  2020
. . write       You must type one of the word above or A, or B, or C.
```

```
. endq
endloop
do      quit

$$*******************************************************************
unit    checkprac
define  element : string
define  i : integer
open    "orthol.log",l,read
for i := 1,3
. get   l,element
. if element = "T"
. . assign      checkp[i] := true
. else
. . assign      checkp[i] := false
. endif
endfor
for i := 1,10
. get   l,element
. if element = "T"
. . assign      checkr[i] := true
. else
. . assign      checkr[i] := false
. endif
endfor
close   l,delete

$$*******************************************************************
unit    setid
erase
fcolor  red
rorigin 14,10
rbox    0,0;740,459:-6
fcolor  cyan
size    2,3
at      80,100
write   Please enter your username
        and press <RETURN>.
input   80,240
assign  ssno := RESPONSE

$$*******************************************************************
unit    menu
fcolor  red
erase
box     0,0;0.999,0.999
at      210
size    2
fcolor  cyan
write   This lesson lets you review
        orthographic drawing and
        practice some problems.
at      820
write   Do you want to
fcolor  red
```

```
at      1020
write   (A). Practice
at      1220
write   (B). Quit
at      1420
write   (C). Review
fcolor  green
at      1720
write   Please type A, B, or C
        and press <RETURN>

$$*********************************************************************
unit    menu1
erase
box     0,0;0.999,0.999
at      80,10
size    2
fcolor  cyan
write   This unit lets you practice
        20 problems related to
size    1,3
at      50,100
fcolor  green
write   (A). Checking whether you actually understand
             the basic concepts of orthographic drawing, (5 problems)
at      50,180
write   (B). Identifing multiple views with the given
             pictorial view and vice versa.(5 problems)
at      50,270
write   (C). finding a correct or incorrect right side view
             for the given top and front views.(10 problems)
at      80,340
fcolor  red
size    1,2
write   You are encouraged to do A first, then B, then C.
        Please type A, B, C, OR Q(to quit).

$$*********************************************************************
unit    practice
erase
define  i,j : integer
assign  go_on1 := true
assign  percent := 0
loop    go_on1
. do    menu1
. fcolor        yellow
. at    10,100
. if checkP[1] = true
. . write       T
. else
. . write       N
. endif
. at    10,180
. if checkP[2] = true
. . write       T
```

```
. else
. . write       N
. endif
. at    10,270
. if checkP[3] = true
. . write       T
. else
. . write       N
. endif
. at    20,400
. write NOTE: T  indicates that you have practiced that section.
              N  indicates that you have NOT practiced that section.
. query
. right a|A
. . do  prac1
. . assign      checkPP[1] := true
. . assign      percent := 100*(5/count)
. . do  shoscore
. right b|B
. . do  prac2
. . assign      checkPP[2] := true
. . assign      percent := 100*(5/count)
. . do  shoscore
. right c|C
. . do  prac3
. . assign      checkPP[3] := true
. . assign      percent := 100*(10/count)
. . do  shoscore
. right q|Q
. . assign      go_on1 := false
. . erase
. wrong
. . erase       15,330;760,460
. . at  80,350
. . size        1
. . fcolor      red
. . write       You must type one of A, B, C, or Q
. endq
endloop

$$**********************************************************************
unit    prac1
define  i,m,n, numtry : integer
define  continue : boolean
assign  continue := true
assign  m := 3
seed
assign  n := randomu(1,p+1)
for     i := 1,p
. assign        numtry := 0
. assign        n := ((n + m) mod p)
. slide "class:"+array1[n+1,1]+".pic"
. fcolor        red
. size  1
. at    50,300
```

```
. write Enter your answer either A, B, C, or D and press <RETURN>.
. input 50,340
. assign        continue := true
. loop  continue
. . assign      numtry := numtry + 1
. . if ((RESPONSE = array1[n+1,2]) or (RESPONSE = array1[n+1,4]))
. . . at        50,360
. . . size      2
. . . fcolor    yellow
. . . write     Congratulations!
                Your answer is correct.
                press <RETURN> to continue.
. . . pause
. . . assign    continue := false
. . . erase
. . else
. . . size      1,2
. . . fcolor    yellow
. . . at        80,340
. . . write      is not a correct answer.
. . . if ((numtry = 1) or (numtry = 2))
. . . . at      80,380
. . . . write   you need review following unit.
                press <RETURN> to begin review.
. . . . pause
. . . . if (n+1) = 1
. . . . . do    r4
. . . . else
. . . . . if (n+1) = 2
. . . . . . do  r2
. . . . . else
. . . . . . . if (n+1) =3
. . . . . . . . do        r7
. . . . . . . else
. . . . . . . . if (n+1) = 4
. . . . . . . . . do  r8
. . . . . . . . else
. . . . . . . . . do  r10
. . . . . . . . endif
. . . . . . . endif
. . . . . . endif
. . . . endif
. . . . slide   "class:"+array1[n+1,1]+".pic"
. . . . at      50,300
. . . . size    1,2
. . . . fcolor  red
. . . . write   Enter your answer either A, B, C, or D and press <RETURN>.
. . . . input   50,340

. . . else
. . . . assign  continue := false
. . . . size    2
. . . . at      50,380
. . . . write   The correct answer is <<s,array1[n+1,2]>>.
                Study it and press <RETURN> to continue.
```

```
. . . . pause
. . . endif
. . endif
. . assign      count := count + 1
. endloop
endfor
assign  checkP[1] := true
$$**********************************************************************
unit    prac2
define  i,m,n, numtry : integer
define  continue : boolean
assign  continue := true
assign  m := 3
seed
assign  n := randomu(1,p+1)
for     i := 1,p
. assign        numtry := 0
. assign        n := ((n + m) mod p)
. slide "class:"+array2[n+1,1]+".pic"
. fcolor        red
. size  1
. at    50,370
. write Enter your answer either A, B, C, or D, and press <RETURN>.
. input 50,390
. assign        continue := true
. loop  continue
. . assign      numtry := numtry + 1
. . if ((RESPONSE = array2[n+1,2]) or (RESPONSE = array2[n+1,4]))
. . . at        50,410
. . . fcolor    yellow
. . . write     Congratulations!
                Your answer is correct.
                press <RETURN> to continue.
. . . pause
. . . assign    continue := false
. . . erase
. . else
. . . size      1,2
. . . fcolor    red
. . . at        80,390
. . . write      is not a correct answer.
. . . if numtry = 1
. . . . at      80,410
. . . . write   You are recommended to read following message.
                press <RETURN> to look it.
. . . . pause
. . . . slide   "CLASS:"+array2[n+1,3]+".pic"
. . . . pause
. . . . slide   "class:"+array2[n+1,1]+".pic"
. . . . at      50,370
. . . . fcolor  red
. . . . write   Enter your answer either A, B, C, or D, and press <RETURN>.
. . . . input   50,390
. . . else
. . . . if numtry = 2
```

```
. . . . . . fcolor yellow
. . . . . . at    50,410
. . . . . . write You should review following unit.
                  press <RETURN> to begin review.
. . . . . . pause
. . . . . . if (n+1) > 3
. . . . . . . do  r6
. . . . . . else
. . . . . . . do  r9
. . . . . . endif
. . . . . . slide "class:"+array2[n+1,1]+".pic"
. . . . . . fcolor        red
. . . . . . at    50,370
. . . . . . write Enter your answer either A, B, C, or D, and press <RETURN>.
. . . . . . input 50,390
. . . . . else
. . . . . . fcolor        yellow
. . . . . . assign        continue := false
. . . . . . size  2
. . . . . . at    50,410
. . . . . . write The correct answer is <<s,array2[n+1,2]>>.
                  Study it and press <RETURN> to continue.
. . . . . . pause
. . . . . endif
. . . . endif
. . . endif
. . assign      count := count + 1
. endloop
endfor
assign  checkP[2] := true

$$*******************************************************************
unit    prac3
define  i,m,n, numtry : integer
define  continue : boolean
assign  continue := true
assign  m := 3
seed
assign  n := randomu(1,x+1)
for     i := 1,x
. assign        numtry := 0
. assign        n := ((n + m) mod x)
. slide "class:"+array3[n+1,1]+".pic"
. fcolor        red
. size  1
. at    20,350
. write Enter your answer either A, B, C, D, E, F, or G, and press <RETURN>.
. input 20,380
. assign        continue := true
. loop  continue
. . assign      numtry := numtry + 1
. . if ((RESPONSE = array3[n+1,2]) or (RESPONSE = array3[n+1,4]))
. . . at        20,400
. . . size      1
. . . write     congratulations!
```

```
                 Your answer is correct.
                 press <RETURN> to continue.
. . . pause
. . . assign   continue := false
. . else
. . . if         ((numtry = 1) and ((n+1) > 3))
. . . . at       80,380
. . . . write    is not a correct answer.
                 press <RETURN> to look pictorial view.
. . . . pause
. . . . slide    "class:"+array3[n+1,3]+".pic"
. . . . fcolor   yellow
. . . . at       40,380
. . . . size     2
. . . . write    The pictorial view is shown as above.
                 study it and press <RETURN> to try again.
. . . . pause
. . . . slide    "class:"+array3[n+1,1]+".pic"
. . . . at       20,330
. . . . fcolor   red
. . . . size     1
. . . . write    Enter your answer either A, B, C, or D
                 and press <RETURN>.
. . . . input    20,380
. . . else
. . . . if numtry = 2
. . . . . fcolor        yellow
. . . . . at     80,380
. . . . . size   1,2
. . . . . write is not a correct answer.
                You should review following unit.
                press <RETURN> to begin review.
. . . . . pause
. . . . . do     r6
. . . . . slide "class:"+array3[n+1,1]+".pic"
. . . . . fcolor        red
. . . . . at     20,330
. . . . . size   1
. . . . . write Enter your answer either A, B, C, D, E, F, or G
                and press <RETURN>.
. . . . . input 20,380
. . . . else
. . . . . if numtry = 3
. . . . . . at  50,380
. . . . . . fcolor      yellow
. . . . . . size        2
. . . . . . write       is not a correct answer.
                       The correct answer is <<s,array3[n+1,2]>>.
                       Study it and press <RETURN> to continue.
. . . . . . pause
. . . . . . assign      continue := false
. . . . . else
. . . . . . at  80,380
. . . . . . size        1
. . . . . . write       is not a correct answer
```

```
                          Press <RETURN> to see the suggestion
. . . . . . pause
. . . . . . slide        "class:"+array3[n+1,3]+".pic"
. . . . . . pause
. . . . . . slide        "class:"+array3[n+1,1]+".pic"
. . . . . . erase        20,330;750,460
. . . . . . at  20,330
. . . . . . size         1
. . . . . . write        Enter your answer either A, B, C, D, E, F, or G
                         and press <RETURN>.
. . . . . . input        20,380
. . . . . endif
. . . . endif
. . . endif
. . endif
. . assign      count := count + 1
. endloop
. erase
endfor
assign  checkP[3] := true
ERASE
$$*********************************************************************
unit    review
erase
define  i,m : integer
box     0,0;0.999,0.999
size    2
fcolor  green
at      15,10
write   * Type ALL to review all information
          on orthographic drawing.

        * Type a number(1-10) to review
          a specifc one.
fcolor  cyan
at      100,160
size    1
write   1. objectives
        2. introduction
        3. definition of terms
        4. pro and con
        5. projection planes
        6. orthographic views
        7. selecting views
        8. space dimensions
        9. interpretation of orthographic views
        10. classification of lines
assign  m := 160
for i := 1,10
. at    20,m
. if checkR[i] = true
. . fcolor      yellow
. . write       T
. else
. . fcolor      red
```

```
. . write       N
. endif
. assign        m := m + 20
endfor
fcolor  red
at      50,370
write   NOTE: T indicates that you have practiced that section.
              N indicates that you have NOT practiced that section.
query
right   all
. erase
. do    revall
right   1|2|3|4|5|6|7|8|9|10
. box   0,0;0.999,0.999
. do    revone
wrong
. write You must type All or a number from 1 to 10.
        Please try again.
endq
$$*********************************************************************
unit    revall
do      r1
do      r2
do      r3
do      r4
do      r5
do      r6
do      r7
do      r8
do      r9
do      r10
for y := 1,10
. assign        checkR[y] := true
endfor

$$*********************************************************************
unit    shoscore
fcolor  cyan
size    2
at      150,200
test    percent
value   100
. write VERY GOOD
        You got then all right.
value   90..99
. write NOT BAD
        Your score is <<s,percent>> %
value   80..89
. write GOOD
        Your score is <<s,percent>> %
value   0..79
. fcolor        red
. write You should review
        before you practice again.
        Your score is <<s,percent>> %
```

```
endtest
do      record0
at      14,450
size    1
write   Please press <RETURN> to continue.
pause
assign  count := 0
$$*************************************************************************
unit    revone
if response = "1"
. do r1
. assign        checkR[1] := true
else
. if response = "2"
. . do r2
. . assign      checkR[2] := true
. else
. . if response = "3"
. . . do r3
. . . assign    checkR[3] := true
. . else
. . . if response = "4"
. . . . do r4
. . . . assign  checkR[4] := true
. . . else
. . . . if response = "5"
. . . . . do r5
. . . . . assign        checkR[5] := true
. . . . else
. . . . . if response = "6"
. . . . . . do r6
. . . . . . assign      checkR[6] := true
. . . . . else
. . . . . . if response = "7"
. . . . . . . do r7
. . . . . . . assign    checkR[7] := true
. . . . . . else
. . . . . . . if response = "8"
. . . . . . . . do r8
. . . . . . . . assign  checkR[8] := true
. . . . . . . else
. . . . . . . . if response = "9"
. . . . . . . . . do r9
. . . . . . . . . assign        checkR[9] := true
. . . . . . . . else
. . . . . . . . . do r10
. . . . . . . . . assign        checkR[10] := true
. . . . . . . . endif
. . . . . . . endif
. . . . . . endif
. . . . . endif
. . . . endif
. . . endif
. . endif
. endif
```

```
endif

$$***********************************************************************
unit    record0
define  i: integer
define  record : string
open    "ortho.log",5,write
test    ioresult
value   1
value   8
other
. erase
. fcolor        red
. at    20,20
. size  2
. write Error openning file. Data not stored.
        Please report this to your instructor.
. stop
endtest
assign  record := ssno
put     5,record
assign  record := "percent = " + string(percent)
put     5,record
for i := 1,3
. if checkP[i] = true
. . assign record := "practice "+string(i)+" = T"
. . put 5,record
. . assign      checkPP[i] :=false
. endif
endfor
assign  record := "     "
put     5,record
close   5
$$***********************************************************************
unit    record1
define  i: integer
define  record : string
open    "ortho.log",5,write
test    ioresult
value   1
value   8
other
. erase
. fcolor        red
. at    20,20
. size  2
. write Error openning file. Data not stored.
        Please report this to your instructor.
. stop
endtest
assign  record := ssno
put     5,record
for i := 1,10
. if checkR[i] = true
. . assign      record := "review "+string(i)+" = T"
```

```
. . put 5,record
. endif
endfor
assign  record := "     "
put     5,record
close   5

$$***************************************************************************
unit    quit
erase
do      loadcheck
do      record1
fcolor  red
erase
size    5
at      1020
write   GOOD-BYE
box     0,0;0.999,0.999:-10

$$***************************************************************************
unit    loadcheck
define  i : integer
define  element : string
open    "orthol.log",5,write
for i := 1,3
. if checkp[i] = true
. . assign      element := "T"
. else
. . assign      element := "F"
. endif
. put   5,element
endfor
for i := 1,10
. if checkr[i] = true
. . assign      element := "T"
. else
. . assign      element := "F"
. endif
. put   5,element
endfor
close   5

$$***************************************************************************
unit    initial1
assign  array1[1,1] := "t1"
assign  array1[1,2] := "B"
assign  array1[1,3] := "hint1"
assign  array1[1,4] := "b"
assign  array1[2,1] := "t2"
assign  array1[2,2] := "D"
assign  array1[2,3] := "hint2"
assign  array1[2,4] := "d"
assign  array1[3,1] := "t3"
assign  array1[3,2] := "A"
assign  array1[3,3] := "hint3"
```

```
assign  array1[3,4]  := "a"
assign  array1[4,1]  := "t4"
assign  array1[4,2]  := "C"
assign  array1[4,3]  := "hint4"
assign  array1[4,4]  := "c"
assign  array1[5,1]  := "t5"
assign  array1[5,2]  := "D"
assign  array1[5,3]  := "hint5"
assign  array1[5,4]  := "d"

$$***********************************************************************
unit    initial2
assign  array2[1,1]  := "x1"
assign  array2[1,2]  := "B"
assign  array2[1,3]  := "hint2a"
assign  array2[1,4]  := "b"
assign  array2[2,1]  := "x2"
assign  array2[2,2]  := "D"
assign  array2[2,3]  := "hint2a"
assign  array2[2,4]  := "d"
assign  array2[3,1]  := "x3"
assign  array2[3,2]  := "A"
assign  array2[3,3]  := "hint2a"
assign  array2[3,4]  := "a"
assign  array2[4,1]  := "x4"
assign  array2[4,2]  := "C"
assign  array2[4,3]  := "hint2b"
assign  array2[4,4]  := "c"
assign  array2[5,1]  := "x5"
assign  array2[5,2]  := "D"
assign  array2[5,3]  := "hint2b"
assign  array2[5,4]  := "d"

$$***********************************************************************
unit    initial3
assign  array3[1,1]  := "q1"
assign  array3[1,2]  := "E"
assign  array3[1,3]  := "hint3a"
assign  array3[1,4]  := "e"
assign  array3[2,1]  := "q2"
assign  array3[2,2]  := "G"
assign  array3[2,3]  := "hint3a"
assign  array3[2,4]  := "g"
assign  array3[3,1]  := "q3"
assign  array3[3,2]  := "F"
assign  array3[3,3]  := "hint3a"
assign  array3[3,4]  := "f"
assign  array3[4,1]  := "q4"
assign  array3[4,2]  := "A"
assign  array3[4,3]  := "aux4"
assign  array3[5,1]  := "q5"
assign  array3[4,4]  := "a"
assign  array3[5,2]  := "D"
assign  array3[5,3]  := "aux5"
assign  array3[5,4]  := "d"
```

```
assign   array3[6,1] := "q6"
assign   array3[6,2] := "D"
assign   array3[6,3] := "aux6"
assign   array3[6,4] := "d"
assign   array3[7,1] := "q7"
assign   array3[7,2] := "B"
assign   array3[7,3] := "aux7"
assign   array3[7,4] := "b"
assign   array3[8,1] := "q8"
assign   array3[8,2] := "C"
assign   array3[8,3] := "aux8"
assign   array3[8,4] := "c"
assign   array3[9,1] := "q9"
assign   array3[9,2] := "C"
assign   array3[9,3] := "aux9"
assign   array3[9,4] := "c"
assign   array3[10,1]  := "q10"
assign   array3[10,2]  := "A"
assign   array3[10,3]  := "aux10"
assign   array3[10,4]  := "a"

$$**********************************************************************
unit     r1
ERASE
italics 0
fcolor   red
size     1,3
at       14,10
write    I. Objectives of this module:
size     1,2
at       14,450
write    Please press <RETURN> to continue
pause
fcolor   green
at       14,50
write    1. To recognize the essential features of orthographic projection.
pause
at       14,100
write    2. To understand the basic relationship of the principal
            projections (or views)
pause
at       14,150
write    3. To be able to interpret pictorial images of objects or
            conceptual ieas and produce correct orthographic views of
            the objects or ideas.
pause
at       14,220
write    4. To be able to delineate correct solutions to problems.
            This includes: proper convention, correct selection
            of necessary views, and maintaining correct projection.
pause
$$**********************************************************************
unit     r2
erase
ccolor   green
```

```
fcolor  red
size    1,3
at      14,10
write   II. Introduction:
fcolor  green
size    1,2
at      14,50
write   Typically, engineers design and develop machines and structures
        and direct their construction. Furthermore, in order to communicate
        every detail to manufacturing groups, descriptions must be prepared
        that show every aspect of the "shape" and "size" of each part and
        of the complete machine or structure.
at      14,450
fcolor  red
write   Please press <RETURN> to continue
pause
fcolor  green
at      14,160
write   Shape is described by projection, that is, by the process of causing
        an image to be formed by rays of sight taken in a particular direction
        from an object to a picture(projection) plane.
pause
erase
fcolor  green
at      14,10
write
        The method of projection varies according to
        the direction in which the rays of sight
        are taken to the plane.
fcolor  red
at      14,460
write   press <RETURN> to continue
pause
fcolor  green
at      14,110
write   1. When the rays are perpendicular to
           the projection plane, the projective
           method is called "orthographic
           projection" as shown in the
           picture at the right.
do      r2a
pause
fcolor  green
at      14,270
write   2. When the rays are taken to a particular
           station point, the projective method is
           called "perspective projection" as shown
           in the picture at the right.
size    1,2
do      r2b
pause
erase
fcolor  green
at      14,10
write   3. When the rays are at an angle to the projection plane, the
```

```
            projective method is called "oblique projection."
at          14,450
fcolor      red
write       Please press <RETURN> to continue
pause
$$**********************************************************************
unit        r3
erase
size        1,3
fcolor      red
at          14,10
write       III. Definitions:
fcolor      green
size        1,2
at          14,50
write       Some new terms that will be used are defined as follows:
fcolor      red
at          14,450
write       Please press <RETURN> to continue
pause
fcolor      red
at          14,90
size        1,3
write       What is the multiview drawing?
size        1,2
fcolor      green
at          14,130
write       MULTIVIEW DRAWING is a projection drawing that incorporates
            several views of a part or assembly on one drawing.
do          r3a
pause
erase
pattern     solid
fcolor      red
size        1,3
at          14,10
write       What is the projection?
size        1,2
at          14,450
write       Please press <RETURN> to continue
pause
ccolor      red
fcolor      green
size        1,2
at          14,50
write       PROJECTION is a system of representing an
            object by a line drawing (image) on a surface
            (plane) by using imaginary visual rays (projec-
            tors) emanating from various points on the
            object and extending toward the observor until
            they pierce a picture (or projection) plane.
size        1,2
do          r3b

fcolor      red
```

```
size    1,3
at      4,240
write   What is orthographic projection?
fcolor  green
size    1,2
pause
at      4,280
write   ORTHOGRAPHIC PROJECTION is a system of drawing images
        of an object formed by projectors from the object
        perpendicular to one or more desired planes of projection.
size    1,2
do      r3c
$$*****************************************************************
unit    r4
erase
fcolor  red
size    1,3
at      14,10
write   IV. The pro and con of multi-view drawings:
fcolor  green
size    1,2
at      14,50
write   ADVANTAGE - The true shape of every surface(except oblique and
        incline surface) of object can be shown on a parallel plane of
        projection. Therefore, this type of drawing is best for providing
        precese information on the size and shape of an object.
fcolor  red
at      14,450
write   Please press <RETURN> to continue
pause
at      14,150
fcolor  green
write   DISADVANTAGE - It is difficult to visualize an image of the actual
        object from the different drawing(or view) of the faces, because
        each view provides only a 2-dimensional image.
pause
$$*****************************************************************
UNIT    r5
erase
pattern solid
size    1,2
fcolor  red
size    1,3
at      10,10
write   V. Planes of projection:
fcolor  green
size    1,2
at      10,50
write   There are six principal planes of projection,
        coinciding with the six sides of a rectangular
        prism, or projection box as right above.
do      r5a
fcolor  red
at      14,450
write   press <RETURN> to continue
```

```
pause
fcolor  green
at      10,130
write   These six principal planes of projections are:
        horizontal plane(H), frontal plane(F), right
        profile plane(PR), left profile plane(PL),
        botton plane(B), and rear plane(R).
pause
at      10,230
write   Once the images of all surfaces(planes) have
        been projected onto the images planes
        (projection planes), the image planes can
        be placed as right below.
do      r5b
pause
$$**********************************************************************
unit    r6
erase
pattern solid
size    1,2
fcolor  red
size    1,3
at      14,10
write   VI. Orthographic views of an object:
fcolor  green
size    1,2
at      14,60
write   In an orthographic projection system, the views of an object
        are projected perpendicularly onto projection planes with parallel
        projectors. For example, given a pictorial view(drawing) of
        an object at right,
do      r60
at      14,460
fcolor  red
write   press <RETURN> to continue
pause
fcolor  green
at      14,200
write   to see the front view, the draftperson should imagine that
        he or she is in front of the object, so that the line of sight
        is perpendicular to the frontal projection plane. The resulting
        front view is shown at the right below.
do      r6a
pause
size    1,2
erase   0,200;760,460
fcolor  green
at      14,210
write   to visualize the top view, the observation should be a birds-eye
        view perpendicular to the horizontal plane (that is perpendicular
        to the frontal projection planes). The resulting top view is
        shown at the right below.
do      r6b
pause
size    1,2
```

```
erase   0,210;760,460
fcolor  green
at      14,210
write   to visualize the right-side view, the observation should be
        perpendicular to the right profile plane(that is perpendicular
        to both the frontal and horizontal plane). The resulting right-
        side view is shown at the right below.
do      r6c
pause
size    1,2
erase   0,210;760,460
fcolor  green
at      14,210
write   all three views then should be positioned as follows:

        The top view is over the front view and the right-side view is
        to the right.
do      r6d
pause
erase
fcolor  red
pattern solid
size    1,3
at      14,10
write   VI. Orthographic views of an object:
ccolor  red
fcolor  green
size    1,2
at      14,50
write   We also can imagine that the object has been
        enclosed in a glass box composed of six
        principal projection planes on which the top,
        front, right-side, left-side, bottom, and
        rear views have been projected.
do      r6e
fcolor  red
at      14,460
write   press <RETURN> to continue
pause
ccolor  red
fcolor  green
at      14,180
write   The "box" could then be unfolded
        and laid out in the "standard
        position" as seen below.
do      r6el
pause
size    1,2
$$********************************************************************
unit    r7
erase
fcolor  red
size    1,3
at      14,10
write   VII. Selection of views:
```

```
ccolor   red
fcolor   green
size     1,2
at       14,50
write    As you know, we can draw at least six views of any object.
         This does not mean that all of these views must be used, or
         are needed.
ccolor   green
fcolor   red
at       14,460
write    press <RETURN> to continue
pause
fcolor   green
at       14,110
write    For example, in the following orthographic drawing, we only need
         the top, front, and right-side views because these three views
         already provide a complete shape description. The other views
         should be eliminated.
do       r7a
pause
erase
fcolor   red
size     1,3
at       14,10
write    VII. Selection of views:
size     1,2
at       14,460
write    press <RETURN> to continue
ccolor   red
fcolor   green
ccolor   cyan
fcolor   red
fcolor   green
at       14,60
write    The various views of an object should be carefully selected to
         show every detail of size and shape, as well as the processes to
         be performed. Usually, three views are drawn. However, drawing
         may vary from one or two views for a simple part to four or more
         views for a complicated part or assembly.
pause
at       14,160
write    For example, cylinderical parts and those with a uniform
         thickness can be described in one view. In both cases, notes are
         used to explain the missing feature or dimension. A gasket is an
         example.
do       r7b
pause
$$*******************************************************************
unit     r8
erase
fcolor   red
size     1,3
at       10,10
write    VIII. Three space dimensions:
ccolor   red
```

```
fcolor  green
size    1,2
at      10,40
write   All objects, from single pieces to complicated structures, have
        distinct limits and are measurable by three space dimensions:
ccolor  green
fcolor  red
at      560,60
write   height, width,
at      10,80
write   and depth.
size    1,2
at      14,450
fcolor  red
write   Press <RETURN> to continue
pause
do      r8a
pause
$$*******************************************************************
unit    r9
erase
size    1,3
fcolor  red
at      14,10
write   IX. Interpretation of orthographic projection:
size    1,2
at      14,460
write   press <RETURN> to continue
pause
fcolor  green
at      14,50
write   Interpreting or reading an orthographic drawing is a matter of
        visualizing the object in the form of a 3-dimensional pictorial view.
pause
at      14,100
write   Although this is generally more difficult than constructing an
        orthographic drawing, visualization can be assisted greatly by
        preparation of a freehand pictorial sketch.
pause
erase
at      14,10
write   Interpretation of the drawing will be easier if you remember
        that each line on the drawing represents:
        - the edge of a surface
        - an intersection of two surfaces
        - the boundary or limit of a surface.
do      r9a
fcolor  red
at      334,120
write   NOTE:
size    1,2
size    1,2
at      14,460
write   press <RETURN> to continue
pause
```

```
$$************************************************************************
unit     r10
erase
fcolor   red
size     1,3
at       14,10
write    X. Classification of lines:
at       14,50
size     1,2
fcolor  .green
write    Three types of finished lines are used in the context of orthographic
         drawing are described as follows:
at       14,460
fcolor   red
write    press <RETURN> to continue
pause
at       14,100
fcolor   green
write    1. object lines: They sometimes are referred to as visible lines.
                          they are shown on a drawing by dark, bold lines
                          that represent the outline of the visible object.
do       r10a
pause
fcolor   green
AT       14,180
write    2. hidden lines: They are used to show details that are behind
                          some parts of the object. They are shown on a drawing
                          by a line made of short dashes(or dots).
pause
at       14,260
write    3. center lines: Center lines are used to locate the centers of
                          a symmetrical object and path of motion.
pause
$$************************************************************************
unit     cover
erase
size     1,2
fcolor   red
rorigin 14,10
rsize    1,1
rotate   0
rbox     0,0;740,459:-6
ccolor   red
fcolor   yellow
rorigin 24,20
rsize    1,1
rotate   0
rbox     0,0;720,439:-6
fcolor   green
rorigin 264,290
rsize    1.0,1
rotate   0
rcircle 0,0:30
rorigin 264,290
rsize    1.0,1
```

```
rotate  0
rcircle 0,0:50
rorigin 214,290
rsize   1,1
rotate  0
rat     0,0
rline   0,0
rline   0,70
rline   40,70
rline   40,60
rline   60,60
rline   60,70
rline   190,70
rline   190,50
rline   100,50
rline   100,0
rorigin 404,340
rsize   1,1
rotate  0
rat     0,0
rline   0,0
rline   -110,-90
rorigin 214,220
rsize   1,1
rotate  0
rat     0,0
rline   0,0
rline   0,-100
rline   100,-100
rline   100,-90
rat     80,-90
rline   80,-90
rline   190,-90
rline   190,-70
rline   80,-70
rline   100,-70
rline   100,0
rline   0,0
rat     100,-10
rline   100,-10
rline   190,-10
rline   190,-70
rat     220,120
rline   220,120
rline   220,20
rline   320,20
rline   320,120
rline   310,120
rat     310,30
rline   310,30
rline   310,120
rat     290,120
rline   290,120
rline   290,30
rat     220,120
```

```
rline    220,120
rline    320,120
rat      230,120
rline    230,120
rline    230,140
rline    310,140
rline    310,120
rorigin  364,180
rsize    1.0,1
rotate   0
rcircle  0,0:10
pattern  dot
rorigin  374,340
rsize    1,1
rotate   0
rat      0,0
rline    0,0
rline    0,20
rat      -20,20
rline    -20,20
rline    -20,0
rat      -160,-130
rline    -160,-130
rline    -60,-130
rat      -80,-210
rline    -80,-210
rline    -160,-210
rat      -140,-220
rline    -140,-220
rline    -140,-120
rat      -120,-130
rline    -120,-130
rline    -120,-210
rat      -100,-210
rline    -100,-210
rline    -100,-130
rat      60,-80
rline    60,-80
rline    160,-80
rat      60,-20
rline    60,-20
rline    160,-20
rat      70,10
rline    70,10
rline    150,10
rat      90,0
rline    90,0
rline    90,20
rat      110,20
rline    110,20
rline    110,0
rorigin  294,220
rsize    1,1
rotate   0
rat      0,0
```

```
rline   0,0
rline   0,-100
pattern dashdot
rorigin 204,290
rat     0,0
rline   0,0
rline   120,0
rorigin 424,290
rat     0,0
rline   0,0
rline   120,0
rorigin 264,100
rat     0,0
rline   0,0
rline   0,270
rorigin 344,180
rat     0,0
rline   0,0
rline   40,0
rat     20,-20
rline   20,-20
rline   20,20
rorigin 364,330
rat     0,0
rline   0,0
rline   0,40
rorigin 474,330
rat     0,0
rline   0,0
rline   0,40
fcolor  red
pattern solid
size    3,7
at      114,40
write   ORTHOGRAPHIC DRAWING
ccolor  red
fcolor  magenta
size    2,4
at      144,390
write   DESIGNED BY: WEN-SHUNG TAI
size    1,2
fcolor  red
rorigin 14,10
rsize   1,1
rbox    0,0;740,459:-6
$$**********************************************************************
UNIT    r2a
pattern solid
size    1,2
fcolor  yellow
rorigin 564,100
rsize   1,1
rotate  0
rat     0,0
rline   0,0
```

```
rline   0,-50
rline   60,-30
rline   90,0
rline   90,30
rline   0,0
rat     90,-80
rline   90,-80
rline   0,-50
rat     90,-80
rline   90,-80
rline   150,-60
rline   60,-30
rat     90,0
rline   90,0
rline   180,-30
rline   150,-60
rat     180,-30
rline   180,-30
rline   180,0
rline   90,30
rat     0,0
fcolor  red
pattern dash
rorigin 594,200
rsize   1,1
rotate  0
rat     0,0
rline   0,0
rline   0,-110
rline   -150,-160
rline   -150,-50
rline   0,0
pattern solid
at      574,220
write   projection plane
fcolor  yellow
at      594,40
write   object
at      644,170
write   projectors
fcolor  cyan
rorigin 564,230
rsize   1,1
rotate  0
rvector 0,0;-26,-40:0.2
fcolor  white
pattern dashdot
rorigin 564,50
rsize   0.5,0.5
rotate  0
rat     0,0
rline   0,0
rline   -360,120
rat     120,40
rline   120,40
```

```
rline   -300,180
rat     0,100
rline   0,100
rline   -360,220
rat     180,160
rline   180,160
rline   180,160
rline   -300,300
rat     180,100
rline   180,100
rline   -300,240
fcolor  red
pattern solid
rorigin 444,200
rsize   1,1
rotate  0
rvector 0,0;-66,20:0.2
at      384,230
write   to infinity
fcolor  red
rorigin 474,80
rsize   1,1
rotate  0
rat     0,0
rline   0,0
rline   60,20
rline   80,50
rline   80,80
rline   0,50
rline   0,0
fcolor  cyan
rorigin 634,180
rsize   1,1
rotate  0
rvector 0,0;-16,-40:0.2
rorigin 634,180
rsize   1,1
rotate  0
rvector 0,0;4,-70:0.2
$$*******************************************************************
UNIT    r2b
pattern solid
size    1,2
rorigin 624,270
rsize   0.50999999,0.50999999
rotate  0
rat     0,0
rline   0,0
rline   -120,40
rline   -120,160
rline   120,240
rline   240,200
rline   240,140
rline   120,180
rline   120,240
```

```
rat     -120,40
rline   -120,40
rline   60,100
rline   120,180
rat     60,100
rline   60,100
rline   180,60
rline   240,140
rat     0,0
rline   0,0
rline   180,60
fcolor  red
pattern dash
rorigin 454,320
rsize   0.5,0.5
rotate  0
rat     0,0
rline   0,0
rline   210,70
rline   210,240
rline   0,170
rline   0,0
fcolor  white
pattern dashdot
rorigin 564,290
rsize   0.5,0.5
rotate  0
rat     0,0
rline   0,0
rline   -360,260
rline   0,120
rat     -360,260
rline   -360,260
rline   180,60
rat     -360,260
rline   -360,260
rline   240,200
rat     -360,260
rline   -360,260
rline   240,140
rorigin 624,270
fcolor  green
pattern solid
rat     -300,170
rline   -300,170
rline   -300,230
rline   -180,270
rline   -180,240
rline   -210,200
rline   -300,170
fcolor  green
pattern solid
rorigin 474,359
rsize   0.47999999,0.47
rotate  0
```

```
rat     0,0
rline   0,0
rline   50,-10
rline   130,20
rline   150,50
rline   150,70
rline   120,100
rline   120,70
rline   150,50
rline   130,20
rline   90,30
pattern solid
at      554,460
write   projection plane
at      344,430
write   station point
rorigin 544,470
rsize   1,1
rotate  0
rvector 0,0;-36,-40:0.2
$$*********************************************************************
UNIT    r3a
pattern solid
size    1,2
fcolor  yellow
rorigin 204,310
rsize   1,1
rotate  0
rat     0,0
rline   0,0
rline   -60,0
rline   -60,50
rline   30,50
rline   30,20
rline   0,0
rat     0,-30
rline   0,-30
rline   -60,-30
rline   -60,-90
rline   0,-90
rline   0,-30
rline   30,-30
rline   30,-90
rline   0,-90
rat     60,20
rline   60,20
rline   60,0
rline   130,0
rline   130,20
rline   60,20
rline   60,50
rline   130,50
rline   130,20
fcolor  cyan
at      144,370
```

```
write   front view    right-side view
at.     144,290
write   top view
size    1,2
$$**********************************************************************
unit    r3b
rorigin 564,100
rsize   1,1
rotate  0
rat     0,0
rline   0,0
rline   0,-50
rline   60,-30
rline   90,0
rline   90,30
rline   0,0
rat     90,-80
rline   90,-80
rline   0,-50
rat     90,-80
rline   90,-80
rline   150,-60
rline   60,-30
rat     90,0
rline   90,0
rline   180,-30
rline   150,-60
rat     180,-30
rline   180,-30
rline   180,0
rline   90,30
rat     0,0
fcolor  red
pattern dash
rorigin 594,200
rsize   1,1
rotate  0
rat     0,0
rline   0,0
rline   0,-110
rline   -150,-160
rline   -150,-50
rline   0,0
fcolor  white
pattern dashdot
rorigin 564,160
rsize   1,1
rotate  0
rat     0,0
rline   0,0
rline   90,-30
rat     0,-30
rline   0,-30
rline   90,-60
rat     -30,-60
```

```
rline   -30,-60
rline   60,-90
rat     -90,-80
rline   -90,-80
rline   0,-110
rat     -90,-30
rline   -90,-30
rline   0,-60
fcolor  red
rorigin 564,160
pattern solid
rsize   1,1
rotate  0
rat     0,0
rline   0,0
rline   0,-30
rline   -30,-60
rline   -90,-80
rline   -90,-30
rline   0,0
pattern solid
at      514,210
write   projection plane
at      484,110
write   image
at      594,40
write   object
at      644,170
write   projectors
ccolor  red
fcolor  cyan
rorigin 514,210
rsize   1,1
rotate  0
rvector 0,0;-26,-40:0.2
rorigin 634,180
rsize   1,1
rotate  0
rvector 0,0;-26,-30:0.2
rorigin 634,180
rsize   1,1
rotate  0
rvector 0,0;-26,-60:0.2
rorigin 634,180
rsize   1,1
rotate  0
rvector 0,0;-26,-30:0.2
rorigin 634,180
rsize   1,1
rotate  0
rvector 0,0;-26,-60:0.2
size    1,2
pause
$$*****************************************************************
unit    r3c
```

```
fcolor  cyan
pattern dash
rorigin 534,290
rsize   1,1
rotate  0
rat     0,0
rline   0,0
rline   150,0
rline   150,110
rline   0,110
rline   0,0
ccolor  cyan
fcolor  green
pattern solid
rorigin 564,320
rsize   1,1
rotate  0
rat     0,0
rline   0,0
rline   0,50
rline   90,50
rline   90,20
rline   60,0
rline   0,0
at      584,340
write   image
at      544,380
write   projection plane
size    1,2
pause
$$*************************************************************************
UNIT    r5a
pattern solid
size    1,2
fcolor  cyan
at      580,120
write   F
at      610,80
write   H
at      630,110
write   PR
pattern dot
rorigin 664,150
rsize   1,1
rotate  0
rat     0,0
rline   0,0
rline   -90,-30
rline   -90,-90
rline   -90,-30
rline   -150,-10
pattern solid
rorigin 514,140
rsize   1,1
rotate  0
```

```
rat     0,0
rline   0,0
rline   0,-60
rline   60,-80
rline   150,-50
rline   150,10
rline   90,30
rline   0,0
rat     90,30
rline   90,30
rline   90,-30
rline   150,-50
rat     0,-60
rline   0,-60
rline   90,-30
size    1,2
$$*********************************************************************
UNIT    r5b
pattern solid
size    1,2
fcolor  cyan
at      330,330
write   R
at      430,330
write   PL
at      530,330
write   F
at      590,330
write   PR
at      530,270
write   H
at      530,390
write   B
rorigin 464,320
rsize   1,1
rotate  0
rat     0,0
rline   0,0
rline   0,-60
rline   90,-60
rline   90,0
rline   0,0
rline   0,60
rline   90,60
rline   90,0
rline   150,0
rline   150,60
rline   90,60
rline   90,120
rline   0,120
rline   0,60
rline   -60,60
rline   -60,0
rline   0,0
rline   -150,0
```

```
rline   -150,60
rline   -60,60
size    1,2
$$**********************************************************************
unit    r60
fcolor  cyan
rorigin 544,110
rsize   1,1
rotate  0
rat     0,0
rline   0,0
rline   -30,10
rline   30,30
rline   30,50
rline   60,60
rline   60,90
rline   -30,60
rline   -30,10
rat     0,0
rline   0,0
rline   60,20
rline   30,30
rline   30,50
rline   60,40
rline   60,20
rat     60,40
rline   60,40
rline   90,50
rline   90,80
rline   60,90
rline   60,60
rline   90,50
$$**********************************************************************
unit    r6a
fcolor  cyan
rorigin 264,270
rsize   1,1
rotate  0
rat     0,0
rline   0,0
rline   -30,10
rline   30,30
rline   30,50
rline   60,60
rline   60,90
rline   -30,60
rline   -30,10
rat     0,0
rline   0,0
rline   60,20
rline   30,30
rline   30,50
rline   60,40
rline   60,20
rat     60,40
```

```
rline    60,40
rline    90,50
rline    90,80
rline    60,90
rline    60,60
rline    90,50
ccolor   cyan
fcolor   red
rorigin  54,290
rsize    1,1
rotate   0
rat      0,0
rline    0,0
rline    0,110
rline    150,160
rline    150,50
rline    0,0
at       234,440
write    frontal projection plane
fcolor   white
rorigin  234,450
rsize    1,1
rotate   0
rvector  0,0;-26,-40:0.2
pattern  dashdot
rorigin  234,280
rsize    1,1
rotate   0
rat      0,0
rline    0,0
rline    -150,50
rat      0,50
rline    0,50
rline    -150,100
rat      90,80
rline    90,80
rline    -60,130
rat      90,50
rline    90,50
rline    -60,100
rat      60,40
rline    60,40
rline    -90,90
rat      60,20
rline    60,20
rline    -90,70
ccolor   white
fcolor   yellow
pattern  solid
rorigin  84,330
rsize    1,1
rotate   0
rat      0,0
rline    0,0
rline    0,50
```

```
rline   90,80
rline   90,50
rline   60,40
rline   60,20
rline   0,0
rat     450,0
rline   450,0
rline   450,50
rline   540,50
rline   540,20
rline   510,20
rline   510,0
rline   450,0
fcolor  red
at      534,390
write   front view
size    1,2
$$*****************************************************************************
unit    r6b
fcolor  cyan
pattern solid
rorigin 194,360
rsize   1,1
rotate  0
rat     0,0
rline   0,0
rline   -30,10
rline   30,30
rline   30,50
rline   60,60
rline   60,90
rline   -30,60
rline   -30,10
rat     0,0
rline   0,0
rline   60,20
rline   30,30
rline   30,50
rline   60,40
rline   60,20
rat     60,40
rline   60,40
rline   90,50
rline   90,80
rline   60,90
rline   60,60
rline   90,50
ccolor  cyan
fcolor  red
rorigin 194,280
rsize   1,1
rotate  0
rat     0,0
rline   0,0
rline   -90,30
```

```
rline    60,80
rline    150,50
rline    0,0
at       334,280
write    horizontal projection plane
fcolor   white
rorigin  324,290
rsize    1,1
rotate   0
rvector  0,0;-46,10:0.2
pattern  dashdot
rorigin  194,360
rsize    1,1
rotate   0
rat      0,0
rline    0,0
rline    0,-60
rat      -30,10
rline    -30,10
rline    -30,-50
rat      30,30
rline    30,30
rline    30,-30
rat      60,20
rline    60,20
rline    60,-40
rat      60,-20
rline    60,-20
rat      90,50
rline    90,50
rline    90,-30
ccolor   white
fcolor   yellow
pattern  solid
rorigin  194,300
rsize    1,1
rotate   0
rat      0,0
rline    0,0
rline    -30,10
rline    60,40
rline    90,30
rline    0,0
rat      60,20
rline    60,20
rline    30,30
rat      280,50
rline    280,50
rline    370,50
rline    370,80
rline    280,80
rline    280,50
rat      340,50
rline    340,50
rline    340,80
```

```
fcolor  red
at      484,390
write   top view
$$*********************************************************************
unit    r6c
pattern solid
fcolor  cyan
rorigin 144,280
rsize   1,1
rotate  0
rat     0,0
rline   0,0
rline   -30,10
rline   30,30
rline   30,50
rline   60,60
rline   60,90
rline   -30,60
rline   -30,10
rat     0,0
rline   0,0
rline   60,20
rline   30,30
rline   30,50
rline   60,40
rline   60,20
rat     60,40
rline   60,40
rline   90,50
rline   90,80
rline   60,90
rline   60,60
rline   90,50
ccolor  cyan
fcolor  red
rorigin 264,440
rsize   1,1
rotate  0
rat     0,0
rline   0,0
rline   0,-110
rline   90,-140
rline   90,-30
rline   0,0
at      404,290
write   right profile plane
fcolor  white
rorigin 394,300
rsize   1,1
rotate  0
rvector 0,0;-36,40:0.2
pattern dashdot
rorigin 204,370
rsize   1,1
rotate  0
```

```
rat     0,0
rline   0,0
rline   90,30
rat     30,-10
rline   30,-10
rline   120,20
rat     0,-30
rline   0,-30
rline   90,0
rat     -30,-60
rline   -30,-60
rline   90,-20
rat     0,-70
rline   0,-70
rline   120,-30
rat     30,-40
rline   30,-40
rline   120,-10
ccolor  white
fcolor  yellow
pattern solid
rorigin 294,400
rsize   1,1
rotate  0
rat     0,0
rline   0,0
rline   0,-50
rline   30,-60
rline   30,-10
rline   0,0
rline   0,-30
rline   30,-40
rat     210,-50
rline   210,-50
rline   240,-50
rline   240,0
rline   210,0
rline   210,-50
rat     210,-30
rline   210,-30
rline   240,-30
fcolor  red
at      474,410
write   right-side view
$$*******************************************************************************
unit    r6d
pattern solid
fcolor  cyan
rorigin 234,420
rsize   1,1
rotate  0
rat     0,0
rline   0,0
rline   0,-50
rline   60,-50
```

```
rline   60,-30
rline   90,-30
rline   90,0
rline   0,0
rat     0,-100
rline   0,-100
rline   0,-130
rline   90,-130
rline   90,-100
rline   0,-100
rat     60,-100
rline   60,-100
rline   60,-130
rat     140,-30
rline   140,-30
rline   140,-50
rline   170,-50
rline   170,-30
rline   140,-30
rline   140,0
rline   170,0
rline   170,-30
pattern dashdot
fcolor  yellow
rorigin 234,365
rat     0,0
rline   0,0
rline   0,-40
rat     60,0
rline   60,0
rline   60,-40
rat     90,20
rline   90,20
rline   90,-40
rat     65,5
rline   65,5
rline   135,5
rat     95,25
rline   95,25
rline   135,25
rat     95,55
rline   95,55
rline   135,55
fcolor  red
at      244,330
write   top view
at      234,430
write   front view   right-side view
size    1,2
$$*****************************************************************
UNIT    r6e
pattern solid
size    1,2
rorigin 624,100
rsize   1,1
```

```
rotate   0
rat      0,0
rline    0,0
rline    0,20
rline    30,30
rline    30,60
rline    -60,30
rline    -60,-20
rline    0,0
rline    30,-10
rline    30,10
rline    0,20
rat      30,30
rline    30,30
rline    60,20
rline    60,50
rline    30,60
rat      60,20
rline    60,20
rline    30,10
rat      30,-10
rline    30,-10
rline    -30,-30
rline    -60,-20
ccolor   green
fcolor   red
rorigin  664,230
rsize    1,1
rotate   0
rat      0,0
rline    0,0
rline    0,-130
rline    -210,-200
rline    -210,-70
rline    0,0
rline    90,-30
rline    90,-160
rline    0,-130
rat      90,-160
rline    90,-160
rline    -120,-230
rline    -210,-200
pattern  dash
rorigin  754,200
rsize    1,1
rotate   0
rat      0,0
rline    0,0
rline    -210,-70
rline    -210,-200
rat      -300,-40
rline    -300,-40
rline    -210,-70
ccolor   red
fcolor   magenta
```

```
pattern solid
rorigin 694,180
rsize   1,1
rotate  0
rat     0,0
rline   0,0
rline   0,-50
rline   30,-60
rline   30,-10
rline   0,0
rat     0,-30
rline   0,-30
rline   30,-40
rat     -90,-10
rline   -90,-10
rline   -90,-40
rline   -120,-50
rline   -120,-70
rline   -180,-90
rline   -180,-40
rline   -90,-10
rat     -60,-110
rline   -60,-110
rline   -30,-120
rline   -120,-150
rline   -150,-140
rline   -60,-110
rline   -90,-120
rline   -60,-130
fcolor  cyan
rorigin 634,200
rsize   1,1
rotate  0
rat     0,0
rline   0,0
rline   30,-10
rline   -60,-40
rline   -90,-30
rline   0,0
rat     -150,-90
rline   -150,-90
rline   -120,-100
rline   -120,-150
rline   -150,-140
rline   -150,-90
rat     70,-60
rline   70,-60
rline   70,-90
rline   40,-100
rline   40,-120
rline   -20,-140
rline   -20,-120
rat     50,-70
rline   50,-70
rorigin 704,140
```

```
rat     0,0
rline   0,0
rline   -20,-7
pattern dot
rorigin 604,190
rsize   1,1
rotate  0
rat     0,0
rline   0,0
rline   30,-10
rat     -120,-110
rline   -120,-110
rline   -90,-120
rat     10,-130
rline   10,-130
rline   10,-80
rline   100,-50
$$*********************************************************************
unit    r6el
fcolor  red
pattern solid
rorigin 464,470
rsize   1,1
rotate  0
rat     0,0
rline   0,0
rline   0,-90
rline   -150,-90
rline   -150,0
rline   0,0
rat     0,-90
rline   0,-90
rline   0,-200
rline   -150,-200
rline   -150,-90
rline   -240,-90
rline   -240,-200
rline   -150,-200
rat     0,-200
rline   0,-200
rline   90,-200
rline   90,-90
rline   0,-90
rat     0,-200
rline   0,-200
rline   0,-290
rline   -150,-290
rline   -150,-200
rat     -240,-200
rline   -240,-200
rline   -390,-200
rline   -390,-90
rline   -240,-90
ccolor  red
fcolor  green
```

```
rorigin 464,469
rsize   1,1
rotate  0
rat     0,0
rline   0,0
rat     -30,-30
rline   -30,-30
rline   -30,-60
rline   -120,-60
rline   -120,-30
rline   -30,-30
rat     -30,-120
rline   -30,-120
rline   -30,-150
rline   -60,-150
rline   -60,-170
rline   -120,-170
rline   -120,-120
rline   -30,-120
rat     30,-120
rline   30,-120
rline   30,-170
rline   60,-170
rline   60,-120
rline   30,-120
rat     30,-150
rline   30,-150
rline   60,-150
rat     -30,-230
rline   -30,-230
rline   -30,-260
rline   -120,-260
rline   -120,-230
rline   -30,-230
rat     -60,-230
rline   -60,-230
rline   -60,-260
rat     -180,-120
rline   -180,-120
rline   -180,-120
rline   -180,-170
rline   -210,-170
rline   -210,-120
rline   -180,-120
rat     -270,-120
rline   -270,-120
rline   -270,-170
rline   -330,-170
rline   -330,-150
rline   -360,-150
rline   -360,-120
rline   -270,-120
pattern dot
rorigin 464,470
rsize   1,1
```

```
rotate  0
rat     0,0
rline   0,0
rat     -60,-30
rline   -60,-30
rline   -60,-60
rat     -180,-150
rline   -180,-150
rline   -210,-150
$$*************************************************************************
unit    r7a
pattern solid
fcolor  cyan
rorigin 294,170
rsize   1,1
rotate  0
rat     0,0
rline   0,0
rline   90,0
rline   90,30
rline   0,30
rline   0,0
rline   60,0
rline   60,30
rat     0,80
rline   0,80
rline   60,80
rline   60,100
rline   90,100
rline   90,130
rline   0,130
rline   0,80
rat     140,100
rline   140,100
rline   140,80
rline   170,80
rline   170,100
rline   140,100
rline   140,130
rline   170,130
rline   170,100
rat     -50,80
rline   -50,80
rline   -80,80
rline   -80,130
rline   -50,130
rline   -50,80
rat     -130,80
rline   -130,80
rline   -190,80
rline   -190,100
rline   -220,100
rline   -220,130
rline   -130,130
rline   -130,80
```

```
rat     0,180
rline   0,180
rline   90,180
rline   90,210
rline   0,210
rline   0,210
rline   0,180
pattern dot
rorigin 244,270
rsize   1,1
rotate  0
rat     0,0
rline   0,0
rline   -30,0
rat     110,80
rline   110,80
rline   110,110
ccolor  cyan
fcolor  red
pattern solid
at      304,210
write   top view
at      74,310
write   rear view    L-side V    front view    R-side V
at      294,390
write   bottom view
rorigin 84,220
rsize   1,1
rotate  0
rat     0,0
rline   0,0
rline   70,60
rat     0,60
rline   0,60
rline   70,0
rat     110,0
rline   110,0
rline   180,60
rat     110,60
rline   110,60
rline   180,0
rat     220,120
rline   220,120
rline   290,170
rat     220,170
rline   220,170
rline   290,120
size    1,2
$$*************************************************************************
unit    r7b
pattern solid
ccolor  green
fcolor  cyan
rorigin 284,260
rsize   1.0,0.60000002
```

```
rotate  0
rcircle 0,0:20
rorigin 284,280
rsize   1.0,0.64999998
rotate  0
rcircle 0,0:50
rorigin 264,260
rsize   1,1
rotate  0
rat     0,0
rcurve  0,0;0,20;0,20
rat     40,20
rcurve  40,20;
        40,20;40,0;40,0
rat     -30,20
rcurve  -30,20;
        -30,20;-30,50;-30,50
rat     70,50
rcurve  70,50;
        70,50;70,20;70,20
rorigin 264,280
rsize   1,1
rotate  0
rat     0,0
rcurve  0,0;20,10;40,0;40,0
rat     -30,25
rcurve  -30,25;-30,30;
        -25,45;-10,55;20,60;50,55;65,45;70,30;70,25
rorigin 44,390
rsize   1,1
rotate  0
rat     0,0
rline   0,0
rline   100,0
rline   100,-30
rline   0,-30
rline   0,0
rat     30,-30
rline   30,-30
rline   30,-60
rline   70,-60
rline   70,-30
ccolor  cyan
fcolor  magenta
rorigin 44,400
rsize   1,1
rotate  0
rat     0,0
rline   0,0
rline   0,50
rat     0,40
rline   0,40
rline   100,40
rat     0,50
rline   0,50
```

```
rat      100,50
rline    100,50
rline    100,0
rat      10,30
rline    10,30
rline    0,40
rline    10,50
rat      90,50
rline    90,50
rline    100,40
rline    90,30
rat      30,-80
rline    30,-80
rline    30,-140
rat      70,-140
rline    70,-140
rline    70,-80
rat      0,-130
rline    0,-130
rline    30,-130
rat      70,-130
rline    70,-130
rline    100,-130
rat      20,-140
rline    20,-140
rline    30,-130
rline    20,-120
rat      80,-120
rline    80,-120
rline    70,-130
rline    80,-140
ccolor   magenta
fcolor   cyan
pattern  dashdot
rorigin  94,410
rsize    1,1
rotate   0
rat      0,0
rline    0,0
rline    0,-100
fcolor   red
pattern  solid
at       154,260
write    1 DIA
at       74,440
write    2 DIA
at       204,440
write    (A)                                   (B)
fcolor   cyan
rorigin  484,330
rsize    1.0,0.89999998
rotate   0
rcircle  0,0:50
rorigin  484,330
rsize    1.0,0.89999998
```

```
rotate  0
rcircle 0,0:40
pattern dashdot
rorigin 484,380
rsize   1,1
rotate  0
rat     0,0
rline   0,0
rline   0,10
rline   0,-110
rat     -70,-50
rline   -70,-50
rline   70,-50
trotate 0
pattern solid
rorigin 634,280
rsize   1.0,0.70
rcircle 0,0:40
rorigin 634,280
rsize   1.0,0.7
rcircle 0,0:57
rorigin 577,280
rsize   1,1
rat     0,0
rline   0,0
rline   0,20
rat     114,0
rline   114,0
rline   114,20
rorigin 577,300
rsize   1,1
rat     0,0
rcurve  0,0;4,16;20,32;40,38;57,40;74,38;94,32;110,16;114,0;114,0
rorigin 596,290
rsize   1,1
rat     0,0
rcurve  0,0;3,-6;8,-11;20,-16;38,-18;56,-16;68,-11;73,-6;76,0;76,0
fcolor  red
rorigin 574,380
rsize   1,1
rotate  0
rvector 0,0;-46,-20:0.2
at      584,380
write   1/4 thick
size    1,2
$$*****************************************************************
unit    r8a
fcolor  green
pattern solid
size    1,2
rorigin 184,300
rsize   1,1
rotate  0
rat     0,0
rline   0,0
```

```
rline   0,30
rline   -90,0
rline   -90,-50
rline   -30,-30
rline   -30,-10
rline   0,0
rline   30,-10
rline   30,20
rline   0,30
rat     30,-10
rline   30,-10
rline   0,-20
rline   -30,-10
rat     -30,-30
rline   -30,-30
rline   0,-40
rline   -60,-60
rline   -90,-50
rat     0,-40
rline   0,-40
rline   0,-20
rat     0,0
fcolor  cyan
rorigin 74,290
rsize   1,1
rotate  0
rat     0,0
rline   0,0
rline   -60,-20
rat     0,-50
rline   0,-50
rline   -60,-70
rat     20,-50
rline   20,-50
rline   20,-130
rat     50,-60
rline   50,-60
rline   50,-140
rat     20,-120
rline   20,-120
rline   -10,-110
rat     10,-110
rline   10,-110
rline   20,-120
rline   10,-130
rat     50,-130
rline   50,-130
rline   80,-140
rat     60,-140
rline   60,-140
rline   50,-130
rline   60,-120
rat     -50,-70
rline   -50,-70
rline   -50,-120
```

```
rat     -60,-80
rline   -60,-80
rline   -50,-70
rline   -40,-80
rat     -50,-10
rline   -50,-10
rline   -50,30
rat     -60,0
rline   -60,0
rline   -50,-10
rline   -40,0
rat     20,20
rline   20,20
rline   20,90
rat     110,50
rline   110,50
rline   110,120
rat     20,80
rline   20,80
rline   -10,70
rat     10,70
rline   10,70
rline   20,80
rline   10,90
rat     110,110
rline   110,110
rline   140,120
rat     120,120
rline   120,120
rline   110,110
rline   120,100
rat     0,0
at      110,370
write   width
at      170,140
write   depth
at      10,250
write   height
ccolor  cyan
fcolor  green
rorigin 404,290
rsize   1,1
rotate  0
rat     0,0
rline   0,0
rat     0,20
rline   0,20
rline   0,70
rline   90,70
rline   90,40
rline   60,40
rline   60,20
rline   0,20
rat     0,-50
rline   0,-50
```

```
rline   0,-80
rline   90,-80
rline   90,-50
rline   0,-50
rat     60,-50
rline   60,-50
rline   60,-80
rat     160,20
rline   160,20
rline   190,20
rline   190,70
rline   160,70
rline   160,20
rat     160,40
rline   160,40
rline   190,40
ccolor  green
fcolor  cyan
rorigin 404,300
rsize   1,1
rotate  0
rat     0,0
rline   0,0
rline   0,-30
rat     90,-30
rline   90,-30
rline   90,20
rat     0,-20
rline   0,-20
rline   90,-20
rat     10,-30
rline   10,-30
rline   0,-20
rline   10,-10
rat     80,-30
rline   80,-30
rline   90,-20
rline   80,-10
rat     70,10
rline   70,10
rline   140,10
rat     100,60
rline   100,60
rline   140,60
rat     130,60
rline   130,60
rline   130,10
rat     120,20
rline   120,20
rline   130,10
rline   140,20
rat     120,50
rline   120,50
rline   130,60
rline   140,50
```

```
rat      200,60
rline    200,60
rline    250,60
rat      200,10
rline    200,10
rline    250,10
rat      240,10
rline    240,10
rline    240,60
rat      230,50
rline    230,50
rline    230,50
rline    240,60
rline    250,50
rat      230,20
rline    230,20
rline    240,10
rline    250,20
rat      0,-100
rline    0,-100
rline    0,-150
rat      90,-150
rline    90,-150
rline    90,-100
rat      0,-140
rline    0,-140
rline    90,-140
rat      10,-150
rline    10,-150
rline    0,-140
rline    10,-130
rat      80,-150
rline    80,-150
rline    90,-140
rline    80,-130
rline    80,-130
rorigin  564,300
rsize    1,1
rotate   0
rat      0,0
rline    0,0
rline    0,-30
rat      30,-30
rline    30,-30
rline    30,0
rat      0,-20
rline    0,-20
rline    30,-20
rat      10,-30
rline    10,-30
rline    0,-20
rline    10,-10
rat      20,-10
rline    20,-10
rline    30,-20
```

```
rline   20,-30
rat     -20,-60
rline   -20,-60
rline   -60,-60
rat     -20,-90
rline   -20,-90
rline   -60,-90
rat     -30,-90
rline   -30,-90
rline   -30,-60
rat     -20,-70
rline   -20,-70
rline   -30,-60
rline   -40,-70
rat     -20,-80
rline   -20,-80
rline   -30,-90
rline   -40,-80
at      427,140
write   width
at      427,260
write   width
at      597,270
write   depth
at      547,220
write   depth
at      647,330
write   height
at      507,330
write   height
ccolor  cyan
$$**********************************************************************
UNIT    r9a
pattern solid
size    1,2
fcolor  cyan
rorigin 584,350
rsize   1.0,0.75
rotate  30
rcircle 0,0:32
rorigin 584,310
rsize   0.80000001,0.80000001
rotate  0
rat     0,0
rline   0,0
rline   -60,30
rline   -60,80
rline   0,100
rline   60,70
rline   60,20
rline   0,0
rline   -50,-30
rline   -110,0
rline   -60,30
rat     -110,50
```

```
rline   -110,50
rline   -60,80
rline   -110,50
rline   -110,0
rline   -50,-30
rline   10,-10
rline   60,20
rorigin 304,410
rsize   0.80000001,0.80000001
rotate  0
rat     0,0
rline   0,0
rline   0,-75
rline   75,-112
rline   150,-75
rline   150,0
rline   75,37
rline   0,0
rat     -50,37
rline   -50,37
rline   -50,-112
rat     -150,-112
rline   -150,-112
rline   -150,37
rat     -50,37
rline   -50,37
rline   -50,-112
rat     -50,-200
rline   -50,-200
rline   -150,-200
rat     -50,-350
rline   -50,-350
rline   -150,-350
ccolor  cyan
fcolor  yellow
rorigin 264,410
rsize   0.80000001,0.80000001
rotate  0
rat     0,0
rline   0,0
rline   -100,0
rat     0,-75
rline   0,-75
rline   -100,-75
rat     0,-112
rline   0,-112
rline   -100,-112
rat     0,37
rline   0,37
rline   -100,37
rat     0,-275
rline   0,-275
rline   -100,-275
rat     0,0
ccolor  yellow
```

```
fcolor   cyan
rorigin  264,250
rsize    0.80000001,0.80000001
rotate   0
rat      0,0
rline    0,0
rline    0,-150
rat      -100,-150
rline    -100,-15
rline    -100,0
rorigin  364,380
rsize    1.0,1
rotate   0
rcircle  0,0:42
fcolor   green
at       334,140
write    - green lines represent limit of surface
ccolor   green
fcolor   yellow
at       334,180
write    - yellow lines represent the intersection
           of two surfaces
fcolor   cyan
at       334,240
write    - cyan lines represents the edge of a surface
ccolor   yellow
fcolor   green
pattern  dot
rorigin  264,340
rsize    1,1
rotate   0
rat      0,0
rline    0,0
rline    -80,0
rat      0,80
rline    0,80
rline    -80,80
rat      0,-190
rline    0,-190
rline    -80,-190
rat      0,-110
rline    0,-110
rline    -80,-110
pattern  solid
$$*********************************************************************
UNIT     r10a
pattern  solid
size     1,2
fcolor   cyan
pattern  dashdot
rorigin  584,400
rsize    1,1
rotate   0
rat      0,0
rline    0,0
```

```
rline   0,-60
rline   0,60
rat     -60,0
rline   -60,0
rline   60,0
rat     -100,0
rline   -100,0
rline   -240,0
pattern solid
rorigin 584,400
rsize   1.0,1
rotate  0
rcircle 0,0:50
rorigin 584,400
rsize   1.0,1
rotate  0
rcircle 0,0:30
rorigin 584,400
rsize   1.0,1
rotate  0
rcircle 0,0:10
rorigin 464,370
rsize   1,1
rotate  0
rat     0,0
rline   0,0
rline   -60,0
rline   -60,-20
rline   -60,80
rline   -60,60
rline   0,60
rline   0,0
rat     -60,-20
rline   -60,-20
rline   -100,-20
rline   -100,80
rline   -60,80
pattern dot
rorigin 464,390
rsize   1,1
rotate  0
rat     0,0
rline   0,0
rline   -100,0
rat     0,20
rline   0,20
rline   -100,20
pattern solid
rorigin 414,470
rsize   1,1
rotate  0
rvector 0,0;34,-60:0.2
rorigin 504,360
rsize   1,1
rotate  0
```

```
rvector 0,0;24,40:0.2
rorigin 504,360
rsize   1,1
rotate  0
rvector 0,0;-26,40:0.2
rorigin 514,460
rsize   1,1
rotate  0
rvector 0,0;-46,-30:0.2
rorigin 514,460
rsize   1,1
rotate  0
rvector 0,0;24,-40:0.2
ccolor  cyan
fcolor  yellow
at      434,340
write   center line
at      354,460
write   hidden line    object line
size    1,2
endlesson
```

APPENDIX L. PROCEDURE FOR TEST ADMINISTRATION

Procedure for Test Administration

I. Part One - 10 mins.

Please

1. distribute the "Engineering Graphics and Computer Attitude Scale" to student.
2. tell student to begin his work and write down his username on the test.
3. remind student again to write down his username on attitude scale before collecting the test.
4. collect the attitude scale when student finishes it.

II. Part Two - 50 mins.

Please

1. distribute the "Orthographic Drawing Test" and computer answer sheet to student.
2. tell them to write down his username on both the "Orthographic Drawing Test" and computer answer sheet.
3. when all students complete the student information portion of the answer sheet, tell them to begin work and read the directions for each part carefully.
4. remind student again to write down his username before collecting the test and answer sheet.